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AIR QUALITY INDEX
(AQI) NETWORK DESIGN
FOR
METROPOLITAN TORONTO

January, 1986

Ontario
Ministry
of the
Environment

The Honourable
Jim Bradley
Minister

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Deputy Minister

AIR QUALITY INDEX (AQI) NETWORK DESIGN
FOR
METROPOLITAN TORONTO

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ABSTRACT

This report presents the criteria and procedures for selecting appropriate locations for AQI (Air Quality Index) monitoring stations in Metropolitan Toronto. The approach used may be applied to other urban centres. Special characteristics of the AQI and monitoring objectives are reviewed and clearly defined. Extensive background materials are considered and interpreted.

Procedures are outlined for siting stations to monitor sulphur dioxide, carbon monoxide, oxides of nitrogen, hydrocarbons, and ozone. Probe placement criteria and other practical aspects of specific site selection are discussed. The rationale behind the siting criteria is also given.

The existing ambient air monitoring network is reviewed and the proposed AQI Network presented. Background information such as emission source inventory and site documentation is provided in the Appendices.

EXECUTIVE SUMMARY

As public awareness of air pollution and its effects increases, particularly in densely populated urban centres like Metropolitan Toronto, so does the importance of measurements of air quality levels. When the existing Air Pollution Index (API) system went into effect in 1970, only two parameters, sulphur dioxide and soiling index, were selected. Over the last fifteen years, attention has turned to other pollutants. The API no longer addresses all air quality concerns.

In order to provide the public with a better understanding of the current air quality, a new Air Quality Index (AQI) is being developed. The basis for the AQI will include not only the two pollutants used in the API, but any air contaminant for which real-time monitoring is available and for which there is evidence that an adverse effect on the environment may occur at a known ambient concentration.

This report presents the criteria and procedures for selecting locations for the AQI monitoring stations. It is an attempt to show that the physical characteristics of a sampling site are appropriate to the problems being addressed. The site selection process can be summarized in the form of flow diagrams (as illustrated in Figure E-1) for each of the classical pollutants:

- Sulphur dioxide (SO_2)
- Carbon monoxide (CO)
- Oxides of nitrogen (NO_x)
- Hydrocarbons (H_c)
- Ozone (O_3)

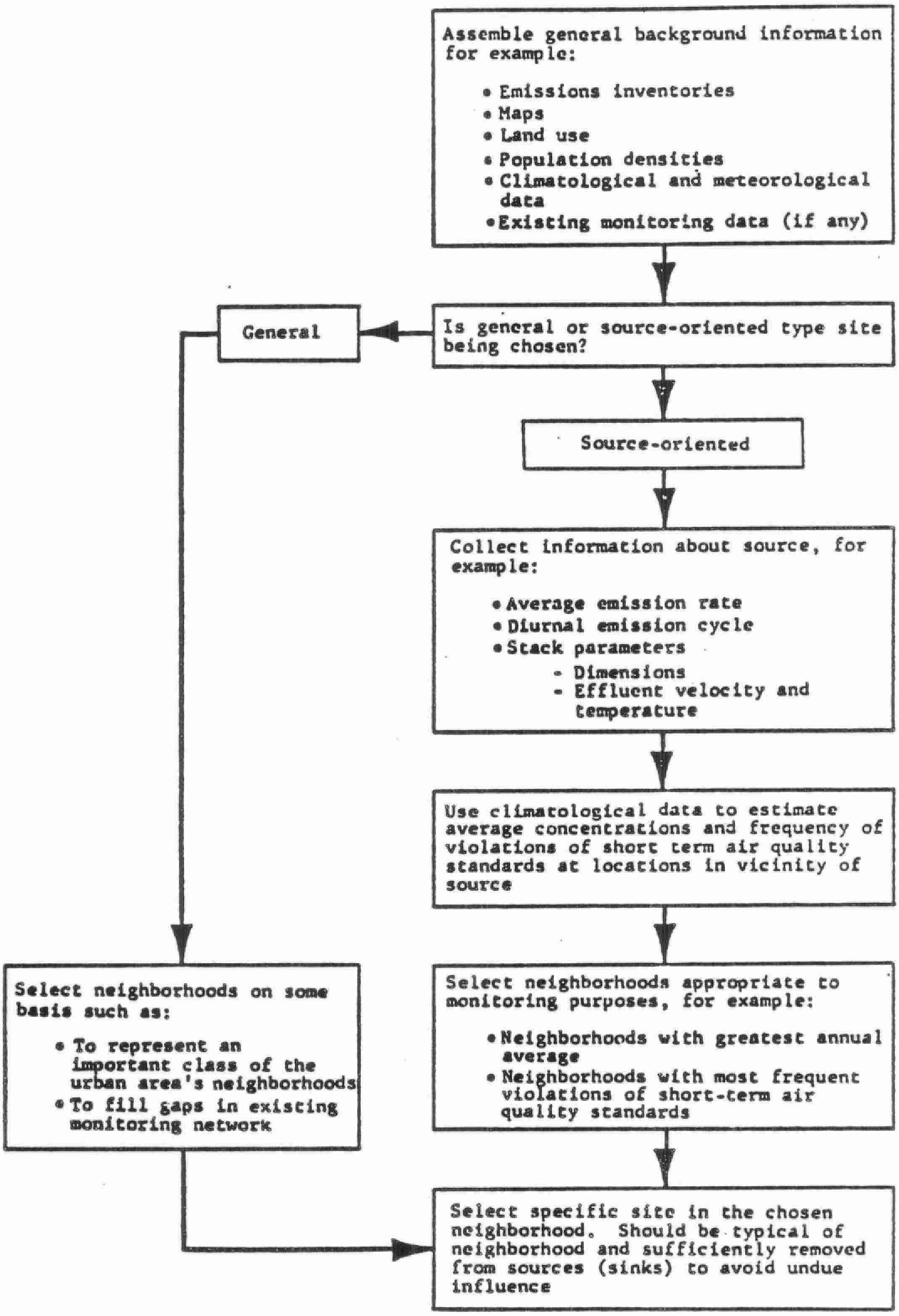

FIGURE E-1 GENERAL PROCEDURE FOR LOCATING NEIGHBORHOOD MONITORING SITES

The basic goal of this monitoring network is to establish the Air Quality Index (AQI) in Metropolitan Toronto. The AQI has been designed to have the following attributes:

- be readily understandable by the public;
- be consistent with perceived air quality;
- include any measured pollutant or combination of pollutants for which there are criteria on effects;
- be able to expand in the future to pollutants not presently measured or for which criteria are at present unavailable; and
- be consistent with the numerical values of the present Air Pollution Index (API) system.

The existing ambient air monitoring network for Metropolitan Toronto was established prior to the reorganization of the Ministry in 1974. The objective was to document the effectiveness of emission regulations in meeting the desirable ambient air quality criteria set forth in the Air Pollution Control Act (1967). The network has since evolved to meet the changing needs of the monitoring program.

The present network (Figure E-2) consists of eight fully-equipped continuous monitoring stations: three in the City of Toronto, two each in North York and Etobicoke, and one in Scarborough. There are no monitoring stations in East York and York. Only six of the eight sites are on the existing telemetry system, whereby real-time data are readily available.

In order to implement the new AQI this spring, three additional stations will be required, one each in North York, East York and York. Two future sites may also be considered, one in Scarborough due to the large geographical area of the municipality, and the other in the high-profile area in South Riverdale (Toronto East).

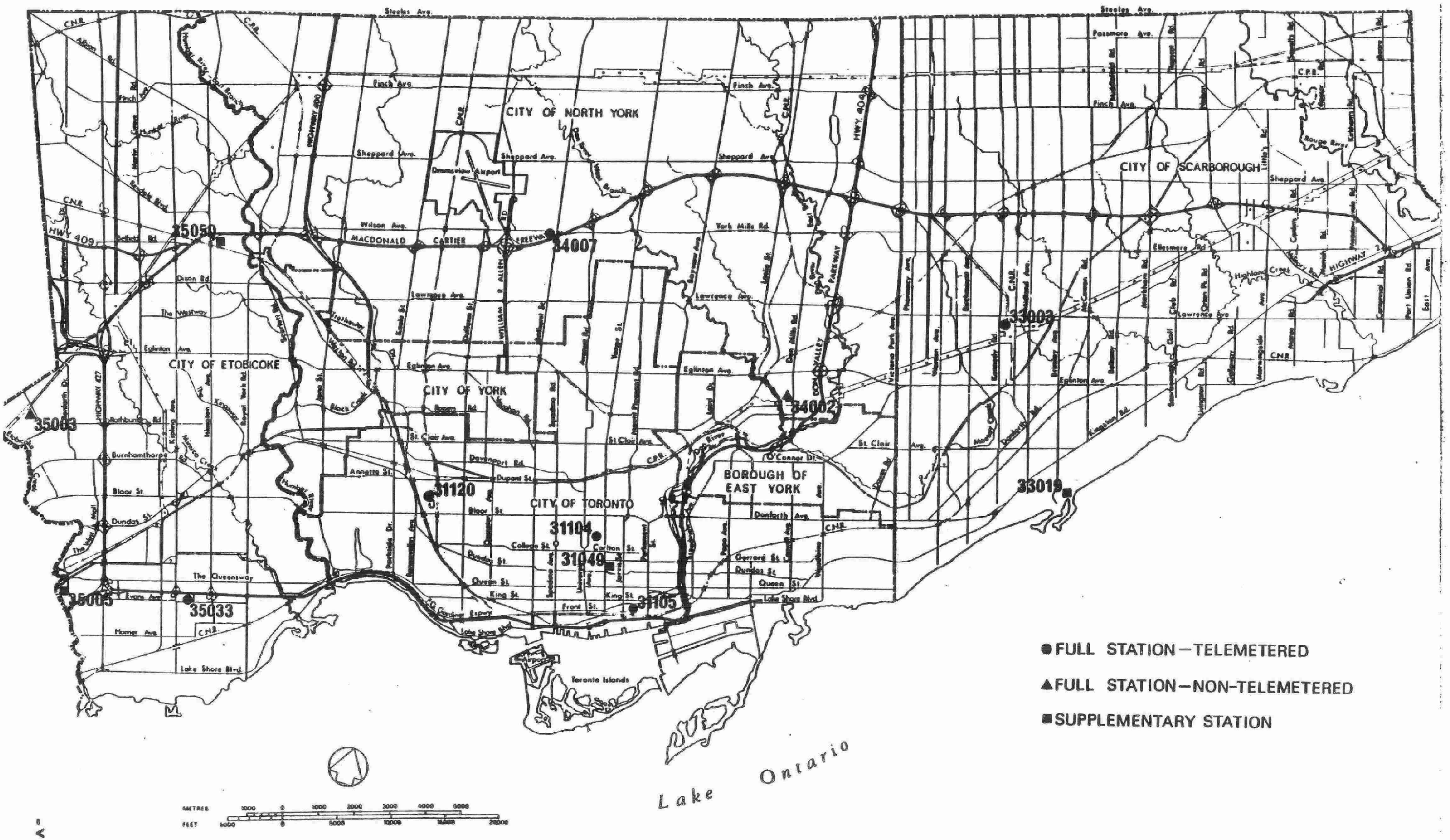

FIGURE E-2 : EXISTING CONTINUOUS AMBIENT AIR MONITORING NETWORK FOR METROPOLITAN TORONTO

A map overlay technique was used in the site selection process, using a land use map as a basis. Since the AQI is concerned with the exposure of the population to air contaminants, areas with the heaviest and sensitive population have been given first consideration for site locations. The effects of natural topography, meteorology, emission sources, and the distribution of complaints were examined.

On the other hand, less desirable areas such as industrial cores, major traffic corridors, and valleys were eliminated as candidate areas for sites. It is known that these areas will not provide representative air quality readings.

Further consideration and refinements were made, ensuring the final prospective areas would meet the monitoring objectives. Field trips to these candidate areas were made and specific sites were selected. Practical aspects of station siting such as power supply, accessibility, and security from vandalism were considered. The final proposed AQI monitoring network is presented in Figure E-3.

Central Region will be the first to implement the AQI and the new telemetry system. Consequently, three new fully-equipped stations will be on-line by Spring 1986. Three existing stations will have to be relocated to achieve better geographical distribution. Two additional stations can be considered for the Scarborough and South Riverdale area. The first AQI will be released in the Spring of 1986.

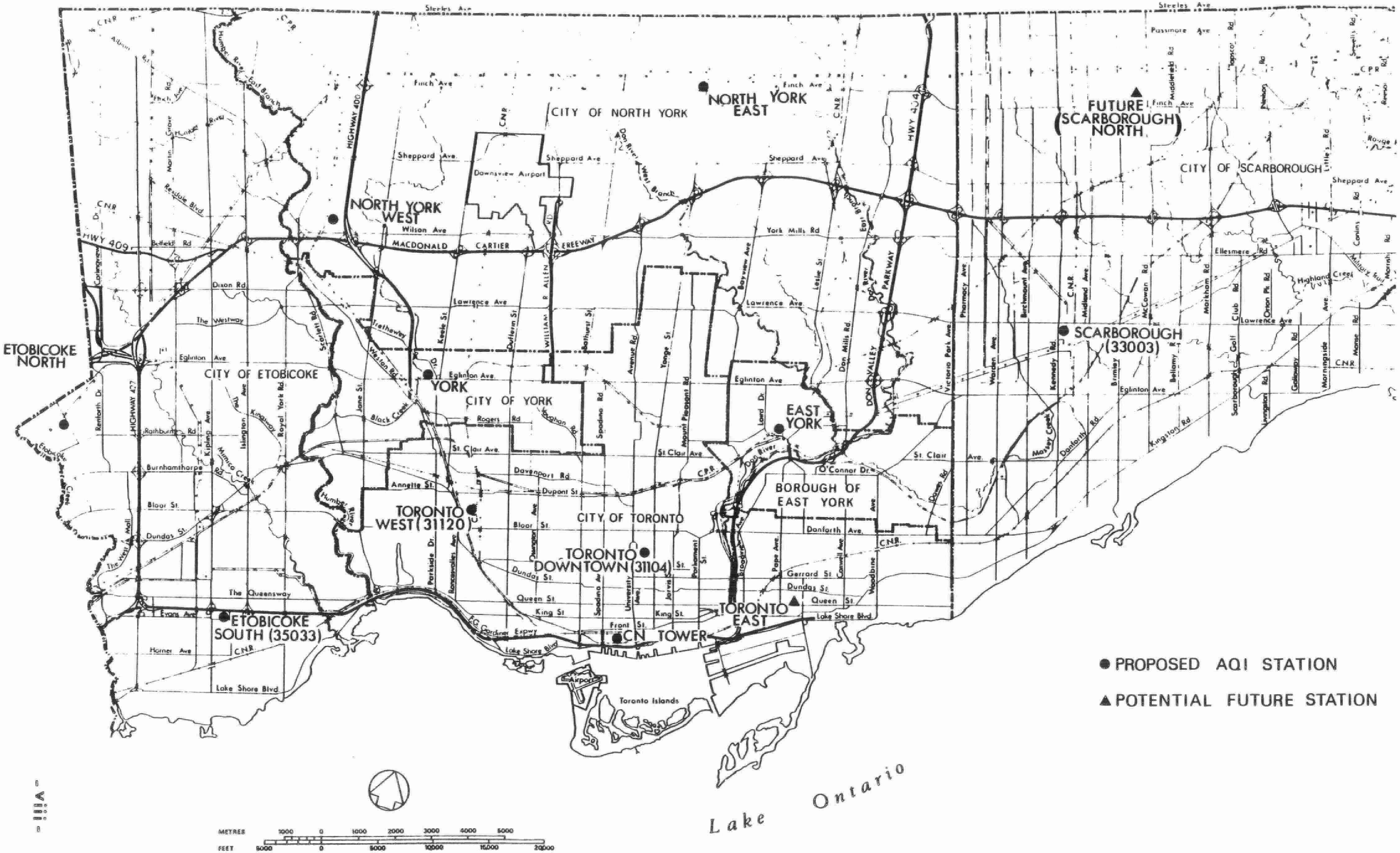

FIGURE E-3: PROPOSED AQI MONITORING NETWORK FOR METROPOLITAN TORONTO

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ACKNOWLEDGEMENT

The author has been greatly assisted by the comments and technical advice of many people, particularly Messrs Peter Fischer (Environmental Approvals and Project Engineering Branch), Darryl Hogg (Central Region), Donald Ogner and Dr. Dave Yap (Air Resources Branch). Their contributions to this project are acknowledged. The writer would also like to thank Mr. Al Little and Ms. Rhonda Lombardi for their assistance in the preparation of this report.

1.0 SUMMARY

As public awareness of air pollution and its effects increases, so does the importance of measurements of air pollution concentrations. In order to provide the public with a better understanding of the current air quality, a new Air Quality Index (AQI) is being developed. The existing ambient air monitoring network in Metropolitan Toronto requires redesign to fully implement the new Index.

This report presents the criteria and procedures for selecting suitable locations for the AQI monitoring stations. It is an attempt to show that the physical characteristics of a sampling site are appropriate to the problems being addressed. The site selection procedures have been summarized in a set of flow diagrams for each of the standard gaseous pollutants:

- Sulphur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Oxides of Nitrogen (NOx)
- Hydrocarbons (Hc)
- Ozone (O_3)

The first and most important step in the design of an air monitoring network is the careful definition of objectives which can assist in making the necessary design and siting decisions. Beside the implementation of the AQI, the basic monitoring objectives can be classified broadly as follows:

- Air quality assessment
- Enforcement of regulations
- Data base for research, etc.
- Support health studies
- Satisfy public demand
- Miscellaneous

Another integral part of the design process is the acquisition and consideration of background material. Such material is extensive, and mainly required to provide information on the physical characteristics of the potential sites. The background information may include:

- maps
- land use
- population density and distribution
- topography
- meteorology
- isopleth maps/emission inventories
- distribution of pollution sources and complaints

The next step is to estimate the number of monitoring stations required. Guidelines related to the AQI must be followed and other factors such as population exposure, area size (scale of representativeness), and high profile areas are considered.

Special characteristics of each of the pollutants are reviewed. For instance, the general network configuration for sulphur dioxide usually displays a rather uniform distribution over the built-up core. It is in contrast to that of carbon monoxide which is neither well-defined nor adequate. However, it is likely that common sites, although not necessarily ideal for each pollutant, may be chosen to give adequate coverage for all the standard pollutants.

A map overlay technique may be used to determine prospective areas within which monitoring stations can be located. Maps of population densities and distribution of sensitive age groups can be prepared to highlight potential areas. Less desirable areas such as industrial cores and traffic corridors are then subtracted from the first set of maps, generating a series of candidate general areas.

Criteria on specific station location are then applied. Practical aspects of site selection such as power supply and accessibility are considered. Co-operation from the municipalities may also be sought to help finalize the proposed monitoring network.

The rationale behind the site selection criteria and guidelines is reviewed so that the methodology may be applied to other monitoring network designs. To complete the design process, other aspects relating to instrument calibration, data recording and transmission methods, data analysis, and the presentation of results are important.

In summary, the approach presented in this report will serve as a technical basis for selecting AQI monitoring sites. The standardization of physical characteristics will ensure compatibility of data to allow comparison among stations. It also provides a physical basis for the interpretation and application of these data.

2.0 INTRODUCTION

2.1 OBJECTIVE

Measurements of air pollution serve a wide range of purposes. Yet, there has seldom been an attempt to confirm that the physical characteristics of a sampling station are appropriate to the problems being addressed.

Non-representative data, apart from being misleading, can be just as costly to obtain as good quality data. The purpose of this report is to identify suitable locations for monitoring the various standard gaseous pollutants, i.e., sulphur dioxide (SO_2), carbon monoxide (CO), oxides of nitrogen (NOx), hydrocarbons (Hc), and Ozone (O_3). The objective of this study is to determine the optimal and cost-effective locations for air monitoring stations in the Metropolitan Toronto area.

2.2 SPECIAL CHARACTERISTICS OF AQI

As public awareness of air pollution and its effects increases, particularly in densely populated urban centres like Metropolitan Toronto, so does the importance of monitoring air pollution levels. When the existing API (Air Pollution Index) system went into effect in 1970, only two pollutants, SO_2 and soiling index (a measure of suspended particulate matter), were selected. Over the last 15 years, attention has turned to other pollutants. The API no longer fully addresses all the air quality concerns.

In order to provide the public with a better understanding of the current air quality, a new Air Quality Index (AQI) is being developed. The basis for the AQI will include, not only those pollutants used in the API, but any air contaminant for which real-time monitoring is available and for which there is evidence that an adverse effect on the

environment may occur at a known ambient concentration. [35] The design of the air monitoring network for Metropolitan Toronto will help achieve the goal of implementing the AQI in Canada's largest city.

2.3 PHILOSOPHY OF APPROACH

The design of an air monitoring network begins by identifying the objective(s). This objective provides a basis for selecting a station type which characterizes the area that the measurements should represent. Siting procedures are then followed that pin-point locations which represent the appropriate areas.

The site selection process is relatively simple but labour-intensive. However, it is unwise to locate an expensive long-term monitoring station without an appropriate expenditure of effort toward site selection. [13] Furthermore, the costs of poor siting procedures can extend well beyond the actual costs of establishing and operating the station. [23] The data obtained may be used as a rationale for urban scale air quality improvement plans with tremendous social or economic impacts, again dictating an intensive network design process.

It is obvious that the project demands time and thought. Also, it is important to obtain and interpret a wide range of background information.

2.4 ORGANIZATION OF THIS REPORT

This report documents the siting procedures for AQI monitoring stations in Metropolitan Toronto. The approach used can also be applied to other urban centres. The primary concerns of the design process are the definition of monitoring objectives and the acquisition of a diverse variety of background material. They are discussed in detail in Section 3.

Section 4 provides the siting criteria and procedures. Each pollutant of interest is carefully examined and included in the design process.

Section 5 shows the siting criteria for specific site location. It deals with constraints such as inlet height, separation distances between sources and inlets, air flow obstruction and so forth.

The rationale behind the siting criteria is presented in Section 6. The reasoning used to derive the site location procedures is documented.

In Section 7, the existing air monitoring network for Metropolitan Toronto is reviewed. The proposed distribution of AQI stations for each of the six municipalities is also presented.

A list of references is included in Section 8. It is by no mean an exhaustive literature review of the subject.

In the Appendices, emission data and site documentation information are illustrated.

3.0 AIR MONITORING OBJECTIVES AND BACKGROUND INFORMATION

The most important factor in the design of an air monitoring network is the careful definition of objectives which can assist in making the necessary design and siting decisions. Such a design should ultimately depend on the reasons for which the monitoring is to be conducted, or the purposes which the data are intended to serve. [5] People may use the data for purposes other than those originally intended by the Ministry.

Another part of the design process is the acquisition and preparation of background material. This material provides information mainly regarding the physical characteristics of the potential sites.

Existing and historical air quality data are essential. Isopleth maps of ambient concentrations are the best tools in determining areas of highest pollution levels. In their absence, emission inventories, land use and wind data can be used to predict areas of higher concentrations.

In addition, information on topography, meteorology, population distribution, existing and future land use, and public complaints is helpful in the site selection process.

3.1 AIR MONITORING OBJECTIVES

The basic goal of this monitoring network is to establish the Air Quality Index (AQI) in Metropolitan Toronto. The AQI was designed to have the following attributes: [35]

a) be readily understandable by the public;

b) be consistent with perceived air quality;

c) include any measured pollutant or combination of pollutants for which there are criteria on effects;

d) be expandable in the future to pollutants not presently measured or for which criteria are at present unavailable; and

e) be consistent in meaning with the numerical values of the present Air Pollution Index (API) system.

The basic objectives are to meet the design criteria of the AQI and to determine representative pollutant concentrations in areas of a high population density. Some of the other objectives can be broadly summarized as follows: [10,26,34,36]

1) to determine general background concentration levels;

2) to assess the region's progress toward meeting ambient air quality standards;

3) to monitor the effectiveness of abatement action and compliance;

4) to discover and define new problems which are necessary in the planning of control strategies;

5) to detect potential pollution episodes under air stagnation conditions and to activate emergency control procedures if required;

6) to observe pollution trends throughout the region;

7) to provide a data base for application in evaluation of effects; urban, land use and transportation planning;

8) to validate and improve the reliability of diffusion models;

9) to determine the risk of damage to especially sensitive receptors;

10) to support epidemiological surveys of health effects associated with measured pollutant levels;

11) to satisfy public demand even though other criteria would not justify air sampling; and

12) to provide data for scientific research.

3.2 OVERVIEW OF METROPOLITAN TORONTO

3.2.1 Physiographic and Topographic

Metropolitan Toronto stretches across about 40 km of the northwestern shore of Lake Ontario and inland for about 20 km. It has a mean sea level elevation of 75 m. The lower city lies upon a plain which slopes northward at a distance of 5 km from the lake, rising at a rate of 9.5-11.5 m/km. Two river valleys, the Don and the Humber, have cut deep ravines in the slope and form the eastern and western boundaries of the central city (Figure 1).

3.2.2 Meteorology

Metropolitan Toronto is located at a latitude of 43°N and is subject to the influence of the prevailing westerlies. Great variability in year-to-year and day-to-day weather is observed as weather systems move rapidly across the Great Lakes Region.

The climate can be classified as humid continental with adequate precipitation in all seasons and temperatures ranging from sub-freezing in winter to very warm in summer. The slow change in the lake water temperature causes seasons to be delayed and moderates temperature extremes in both winter and summer.

During spring and summer, an important influence on the weather as well as pollution concentrations is the lake

FIGURE 1 Metropolitan Toronto

breeze regime. Breezes develop along the shoreline due to the unequal heating of the air over land and water. The lake breeze develops during the day when the land heats faster. At night, the land breeze forms when the cold air drains downslope to the lake.

Another major meteorological effect of Metropolitan areas is the "urban heat island", whereby air temperature in the city exceeds the surrounding suburban and rural areas. Toronto has a fairly regular heat island centered on the urban core with temperature drop off to the suburbs and lake. [18]

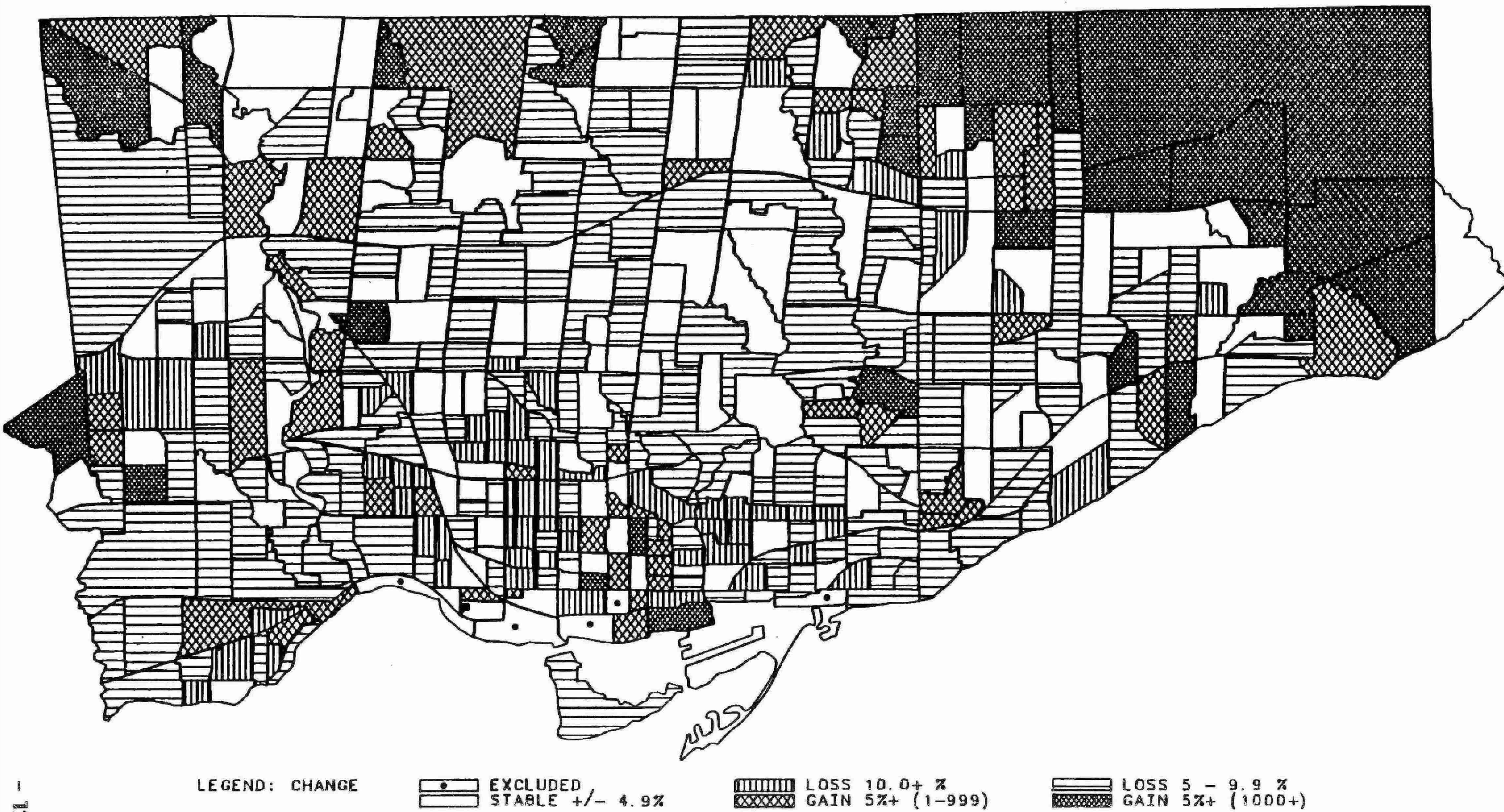
3.2.3 Socio-Economic

Six contiguous boroughs and cities form Metropolitan Toronto, with an area of 855 km^2 and a population of over 3 million. Several satellite communities including Mississauga, Brampton, Oakville, Vaughan, Richmond Hill, Markham, Newmarket, Pickering, Ajax, Whitby, and Oshawa with a combined population of approximately 1.1 million surround the metropolitan area.

Over the ten years from 1971 to 1981, the population of Metropolitan Toronto increased by only 48,000 (2.3%). The increase was a mere 0.6% over the five years from 1976 to 1981 (Figure 2). [24] While population in the Metro area appears to be stabilizing, growth in the neighbouring (satellite) communities is rapid.

The age distribution of the population is currently characterized by a high proportion (about 66%) below 40 years of age. During the last five to ten years, the number of school aged children (6-17 years) declined by 82,000 (19%) from 1971 to 1981. On the other hand, persons aged 65 and over increased by 55,500 (32.5%).

FIGURE 2 PERCENTAGE POPULATION CHANGE, 1976 - 1981



Industries in Metropolitan Toronto are dispersed in pockets: south of the downtown core along the lakeshore in the southeast corner of the city, along the railway corridor running from west of downtown to the northwest corner of the city; and in an area located 12 km east of the downtown core and extending from the lakeshore northward for 10 km. [44]

3.2.4 Air Quality

The Ministry's Central Region operates an extensive air monitoring network in Metropolitan Toronto (refer to Section 7.1). Among the pollutants regularly monitored are sulphur dioxide (SO_2), carbon monoxide (CO), oxides of nitrogen (NO_x), ozone (O_3), soiling index (COH), hydrocarbons (H_C), total suspended particulates (TSP) and its constituents (e.g. lead, sulphate, nitrate), monthly dustfall, and fluoridation rates.

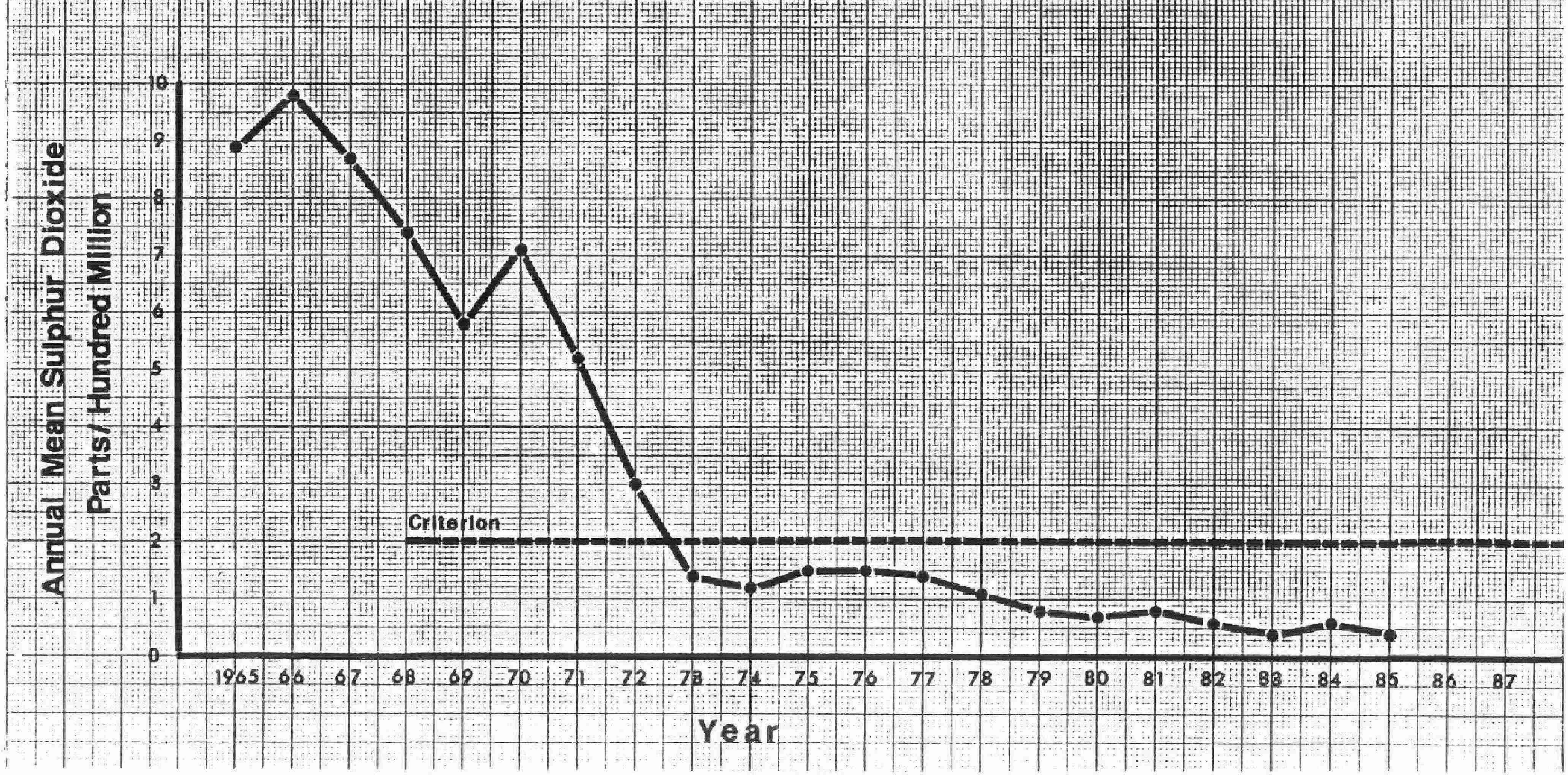
Annual mean SO_2 concentrations are well below the Ontario criteria of 0.02 ppm (Figure 3). The 1-hour and 24-hour criteria have seldom been exceeded. Seasonal variations show higher levels in the winter as a result of space heating requirements.

Automotive emissions contribute heavily to CO and NO_x concentrations, particularly near major traffic corridors. The maximum CO levels have been detected at the downtown street canyon station, whereas the highest NO_x concentrations have been observed along Highway 401 in the north end of the City.

Ozone is the product of photochemical reactions which are most active during peak solar intensity in spring and summer. It is not unusual to have the spring and

Figure 3

Downtown Toronto: Sulphur Dioxide (SO_2)



summer mean O_3 level 2-3 times those in the fall and winter.

Metropolitan Toronto is occasionally subject to high pollution episodes during which stagnant air conditions prevent the dispersal of air pollutants. Associated with the stagnant air masses are clear nights (during which strong surface temperature inversions form), light and variable winds, and temperature inversions aloft.

As a result of these pollution episodes, the Ministry has established an Air Pollution Index (API) based upon 24-hour average SO_2 concentration and particulate matter measured in Coefficient of Haze (COH) units by continuously operated tape samplers. When the API reaches critical levels and adverse weather conditions are expected to continue for at least six hours, the Minister has the power to order the major emitters to reduce their emissions in order to alleviate the severity of the episodes.[18]

Since the API went into effect in 1970, the First Alert Level of 50 has been reached 8 times in Toronto. The maximum API reported was 62 recorded on November 20th, 1975 (Figure 4).

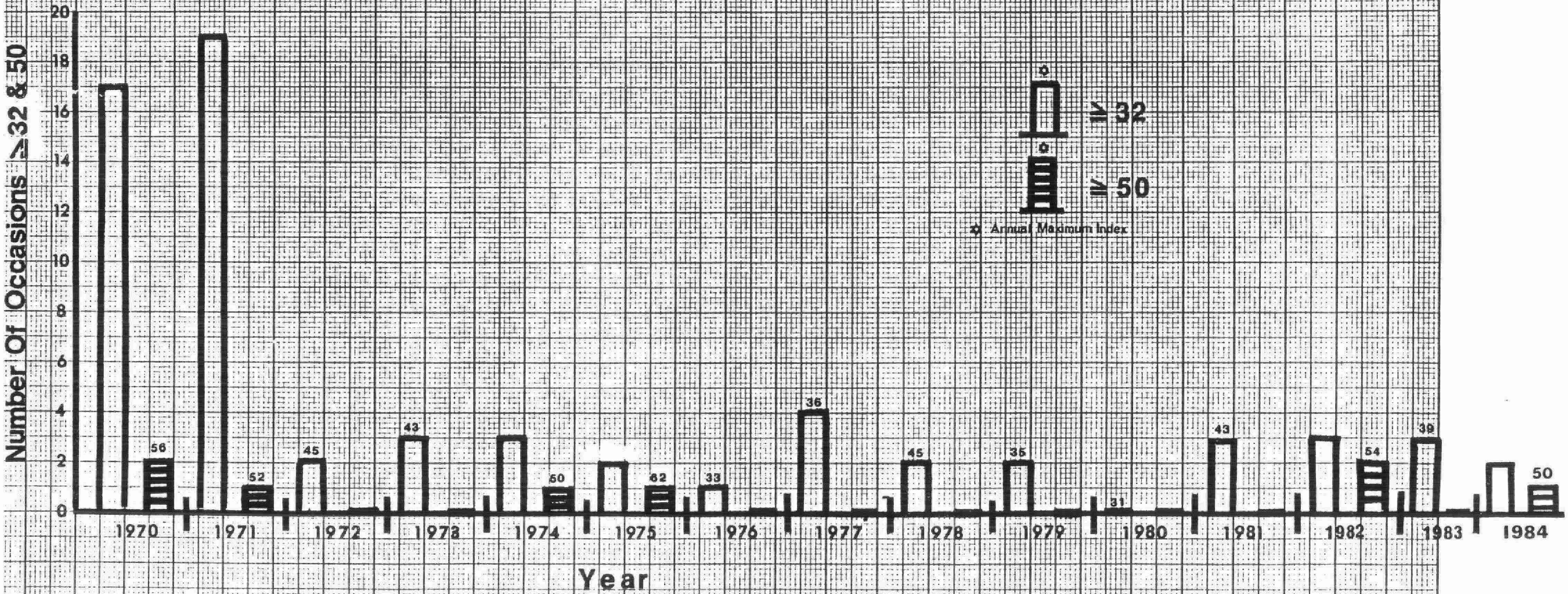
3.3 AIR POLLUTION SOURCES AND EMISSIONS

3.3.1 Major Point Sources

Areas of highest pollution levels, together with geographical and temporal variations in the ambient levels, are essential in network design. One of the best methods of determining where maximum concentrations occur is to use point source diffusion models.

FIGURE 4

Downtown Toronto: Air Pollution Index (API)



Major point sources are stationary sources that contribute significant quantities of pollutants, in excess of 100 lb/day. In 1969, an inventory of 532 point sources was recorded for Metropolitan Toronto. Information for the inventory was obtained through surveys of individual sources by means of completing detailed questionnaire. It required some 10,000 man-hours by Ministry personnel to complete the project.

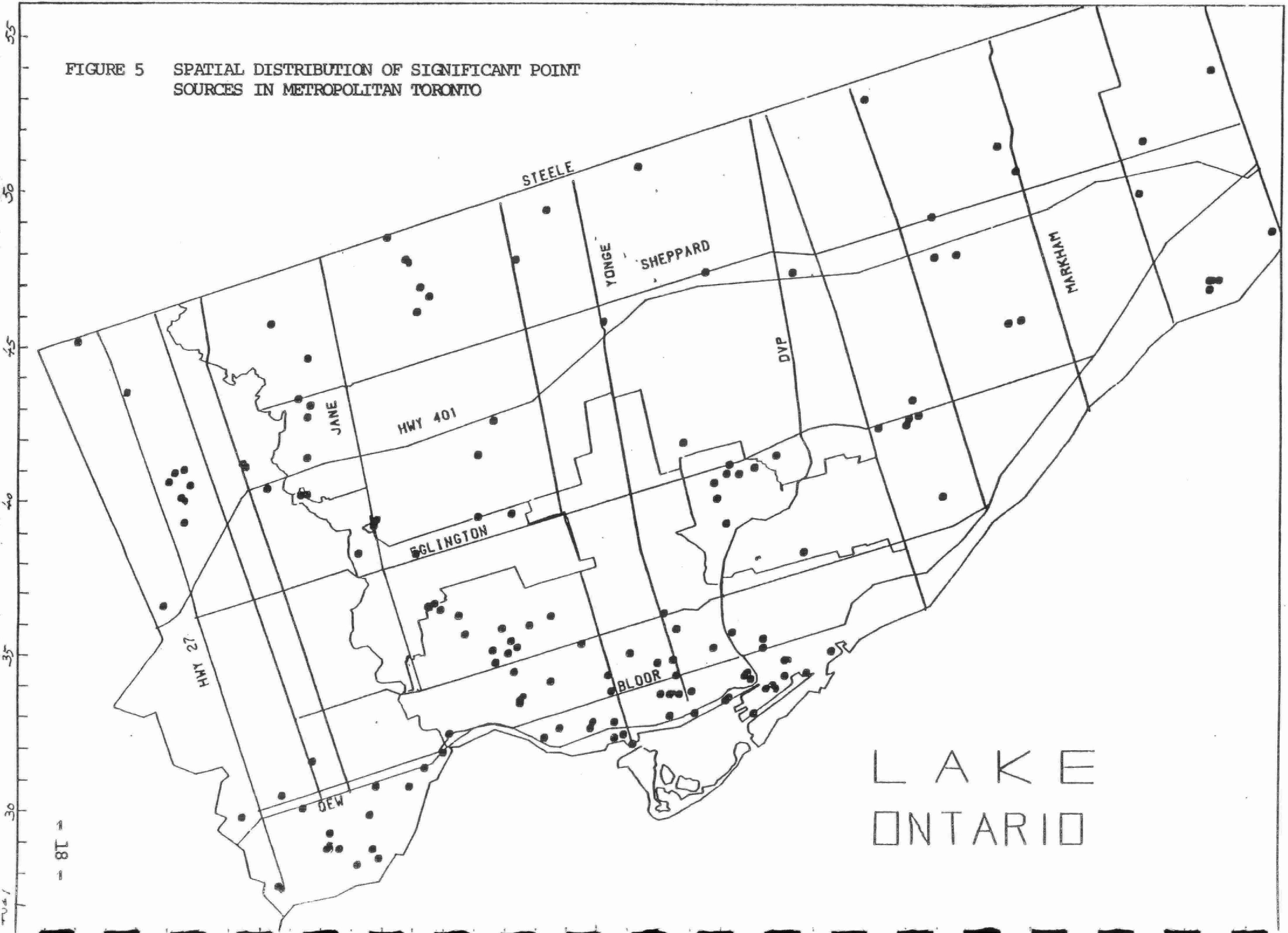
An updated list of the point sources in Toronto was prepared by Central Region's Abatement West staff and is presented in Appendix A. The distribution of these sources is illustrated in Figure 5.

3.3.2 Area Sources

Area sources are smaller compared to major point sources but collectively their contribution can be significant. Vehicular traffic, residential space heating, unpaved roads and parking lots are some of the major contributors.

For area sources, with ground level emissions, the spatial distribution of non-photochemical air pollutants is primarily dominated by the distribution of sources. In Figure 6, Metropolitan Toronto is divided into 5 x 5 km grids. The contribution by area sources to the emission of SO_2, NO_x, CO, particulates, and volatile organic compounds for each of the grid is presented in Table 1.

FIGURE 5 SPATIAL DISTRIBUTION OF SIGNIFICANT POINT SOURCES IN METROPOLITAN TORONTO



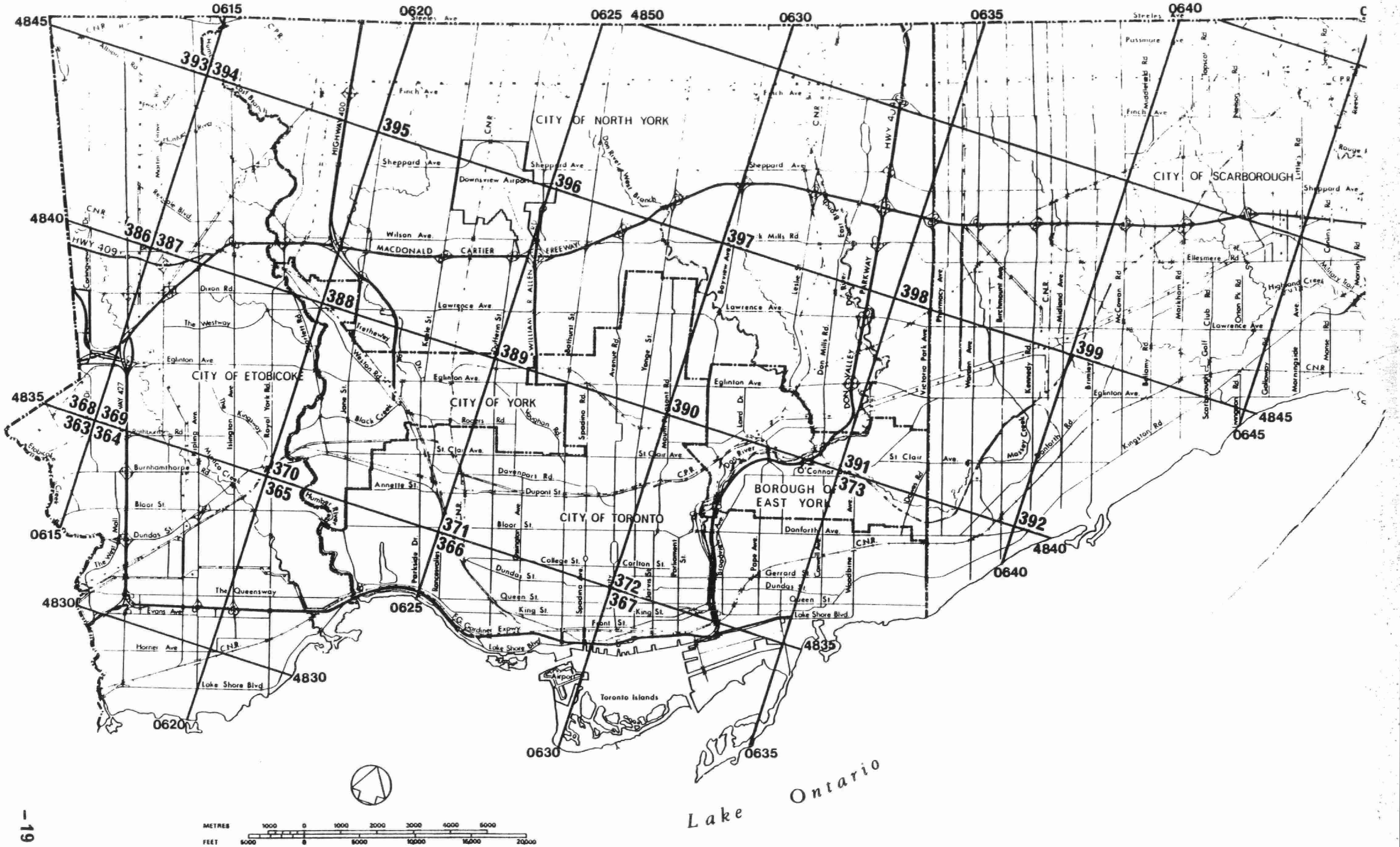


FIGURE 6: METROPOLITAN TORONTO : 5x5 GRID MAP FOR AREA SOURCES

TABLE 1

Emission From Area Sources - Metropolitan Toronto

UNIT : METRIC TONS

# OF UTM GRID	SOX	NOX	CO	PART	VOC	POPULATION
363	235.89	421.91	2344.97	77.24	2087.70	17923
364	740.35	1831.58	11699.84	293.00	6350.36	53768
365	877.50	3067.64	21378.41	443.34	7487.28	59835
366	1446.36	4607.85	31220.90	641.44	13335.98	101876
367	1134.65	1833.54	9621.84	259.17	4125.96	29964
368	699.82	2369.92	13493.05	331.53	5370.63	36602
369	774.88	1863.44	11761.21	301.03	6461.41	56460
370	1926.40	4757.44	29431.70	760.28	16173.32	139505
371	2285.77	6644.29	45474.74	964.81	20402.47	165494
372	2354.27	6194.02	42596.96	3418.66	19214.51	154651
373	1870.17	5493.16	36435.10	853.13	16541.95	134241
386	589.73	1054.76	5862.39	193.11	4779.50	44807
387	934.53	3025.95	21383.00	449.30	7806.97	67102
388	1150.13	4149.15	30026.01	591.58	9638.81	82372
389	1099.37	3462.56	24752.81	866.44	9511.45	77814
390	1141.67	2388.24	14460.08	436.47	10001.66	86842
391	950.18	1989.87	12411.62	343.58	8320.59	73145
392	536.23	1282.59	7918.13	196.71	4630.06	39902
393	358.11	863.63	5616.87	149.51	3071.20	27906
394	529.30	1594.39	11154.03	246.44	4552.92	40353
395	866.17	1679.23	10872.00	1345.44	6816.94	62140
396	1038.47	3037.08	21029.71	463.65	9010.50	78333
397	1041.97	3107.46	21609.54	463.23	9360.56	78333
398	788.33	2838.89	20777.11	394.81	6839.20	55525
399	770.35	2008.50	13657.80	306.41	6801.44	57636
400	536.23	1282.59	7918.13	196.71	4630.06	39902
415	151.70	391.24	2626.71	62.66	1392.92	12377
416	620.82	1739.69	11979.05	263.34	5422.28	46872
417	520.49	1181.68	7796.44	189.84	4563.33	39902
418	795.23	2464.80	17538.60	356.42	6718.38	57636
419	652.70	1746.42	12093.26	265.11	5824.00	48769
427	250.06	667.73	4611.38	104.19	2457.82	21005
428	289.16	565.48	4331.28	105.47	2535.08	22168

* REFER TO FIGURE 6 FOR THE 5X5 GRID MAP.

3.3.3 Current Emission Inventories

Emission inventories provide the basis for an understanding of the air pollution problems. They can also be used in pollution abatement programs, urban planning projects, development of control strategies, and air quality management plans.

These inventories are maintained by the Ministry [41] and will be updated as new information and manpower become available. They consist of sources and quantities of emission of SO_2, NO_x, particulates, CO, and hydrocarbons. Summaries of emissions by source and pollutant in 1980 are shown in Table 2. [18] From these inventories, together with diffusion modeling, emission plots such as those in Figures 7-11 can be deduced.

The major limitation to these figures is that they are based largely on emission data from pre-1975. Very few updates or resurveys have been conducted since that time except for the most significant major point sources. Thus, a good representation of the current emission density for Toronto is lacking, and significant manpower, resources and time are required to update the emission in the Ontario Pollutant Inventory to reflect present conditions.

Table 2

1980 Pollutant Emissions: Percentage By Sources

Toronto

Pollutant	Total Emission Kilo MT	Power Generating Stations	Auto-mobiles	Industrial Sources	Space Heating	Other Sources
SO2	127.9	72 %	2 %	5 %	16 %	5 %
PA	20.6	9 %	28 %	12 %	23 %	28 %
NOx	111.7	22 %	47 %	6 %	10 %	15 %
CO	539.4	+	91 %	+	4 %	5 %
HC*	261.0	+	77 %	3 %	9 %	11 %

* Data based on 1980 VOC Survey

\+ Negligible

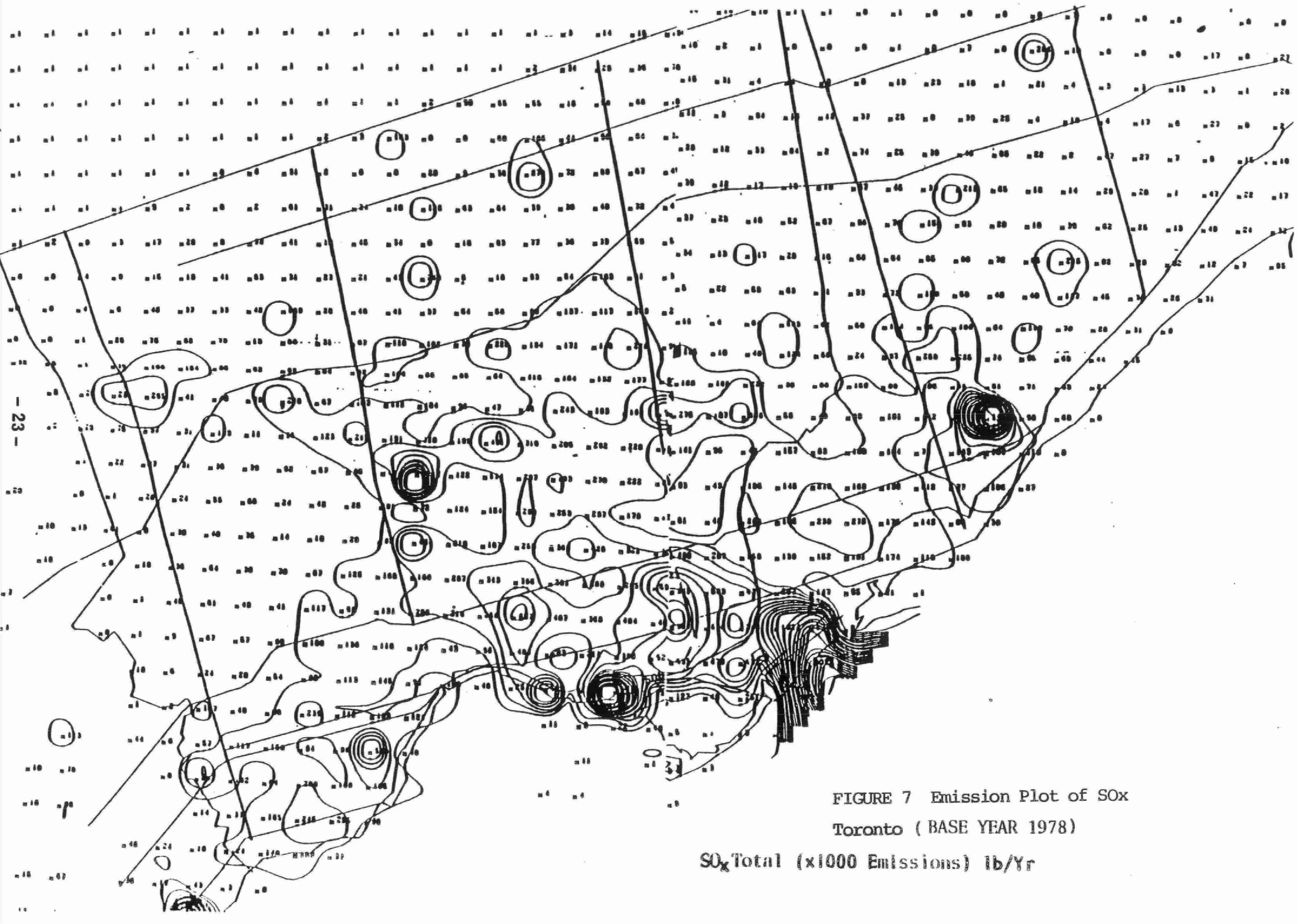


FIGURE 7 Emission Plot of SOx

Toronto (BASE YEAR 1978)

SO_x Total (x1000 Emissions) lb/Yr

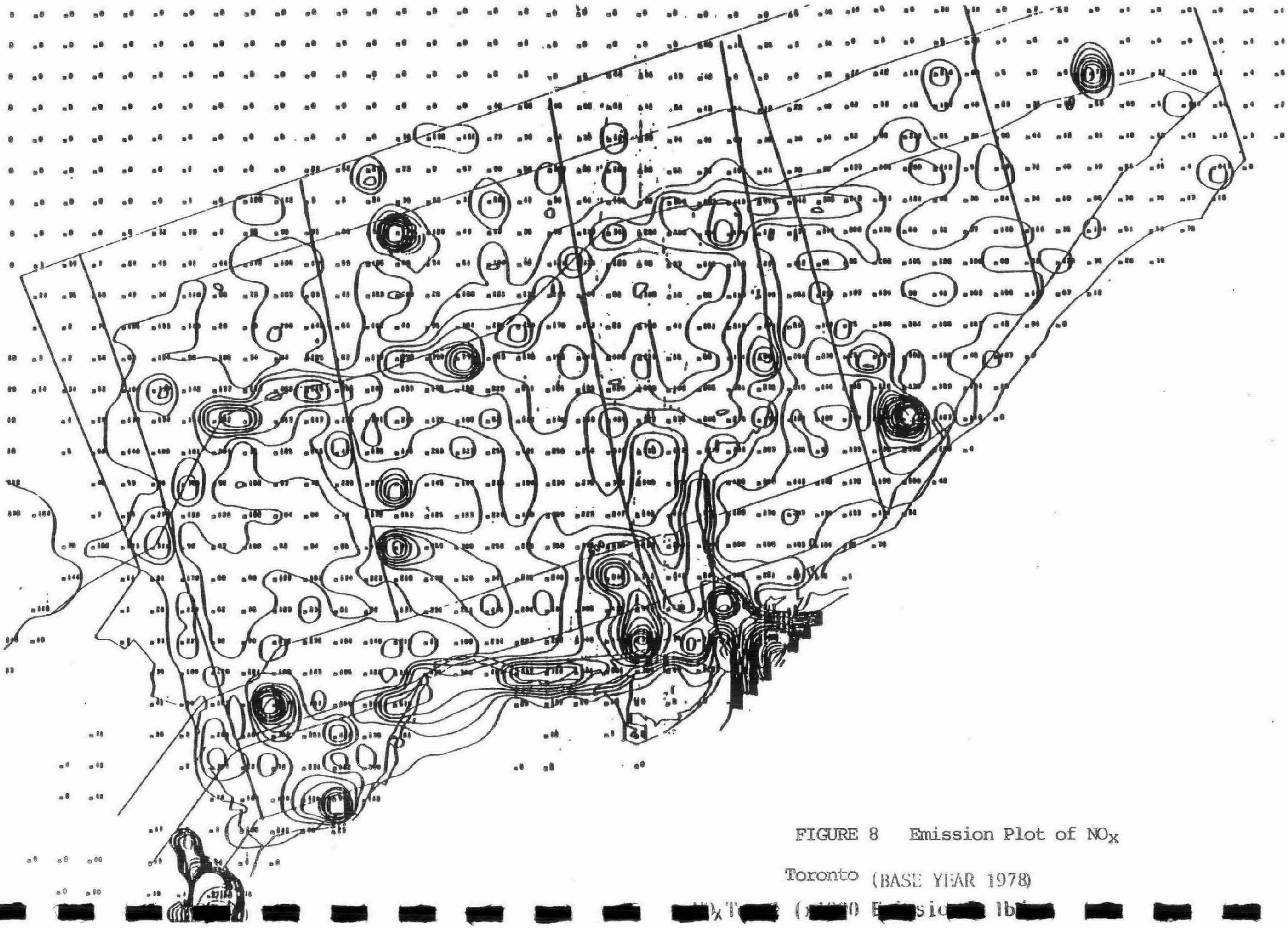


FIGURE 8 Emission Plot of NO_X

Toronto (BASE YEAR 1978)

[redacted]

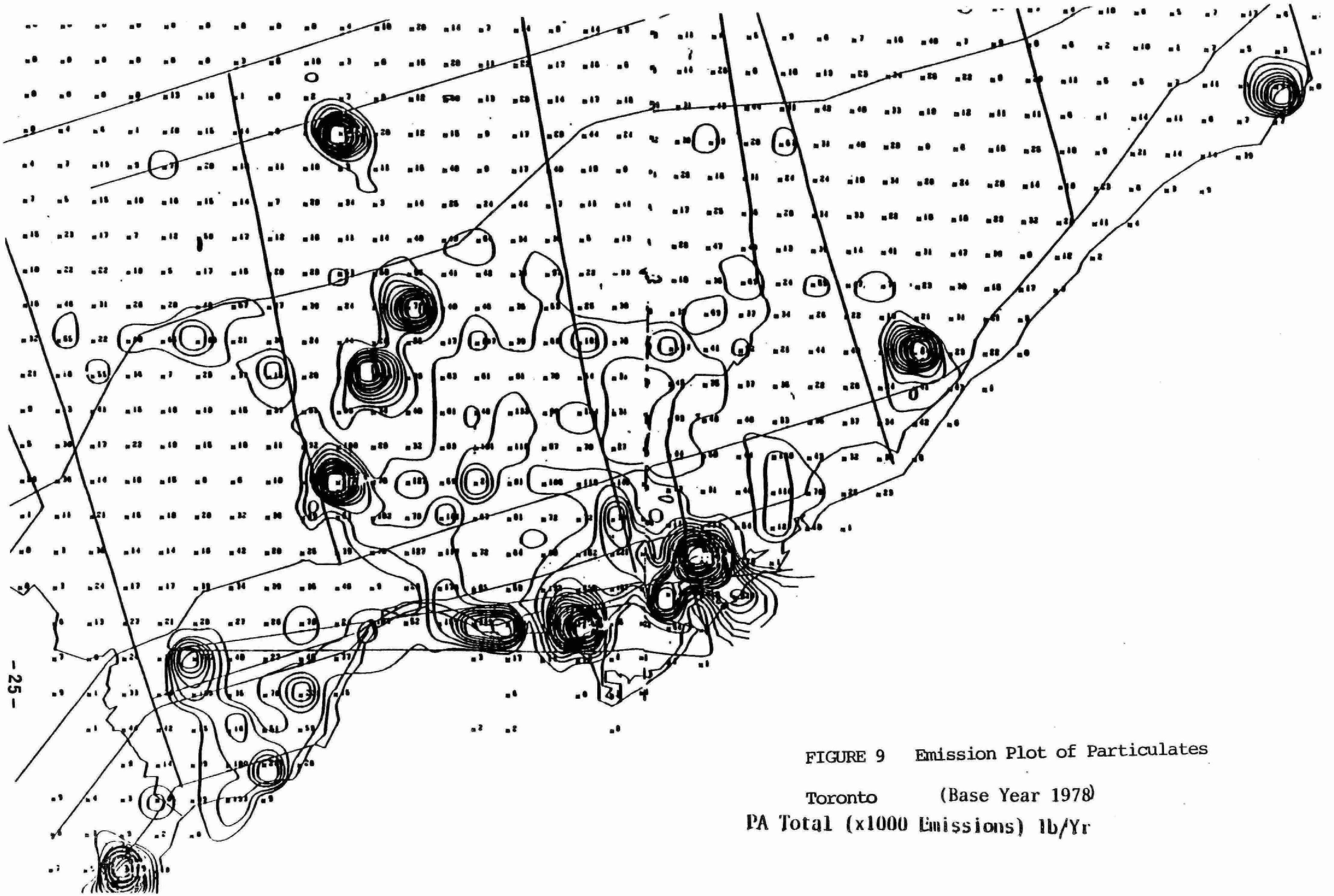


FIGURE 9 Emission Plot of Particulates

Toronto (Base Year 1978)

PA Total (x1000 Emissions) lb/Yr

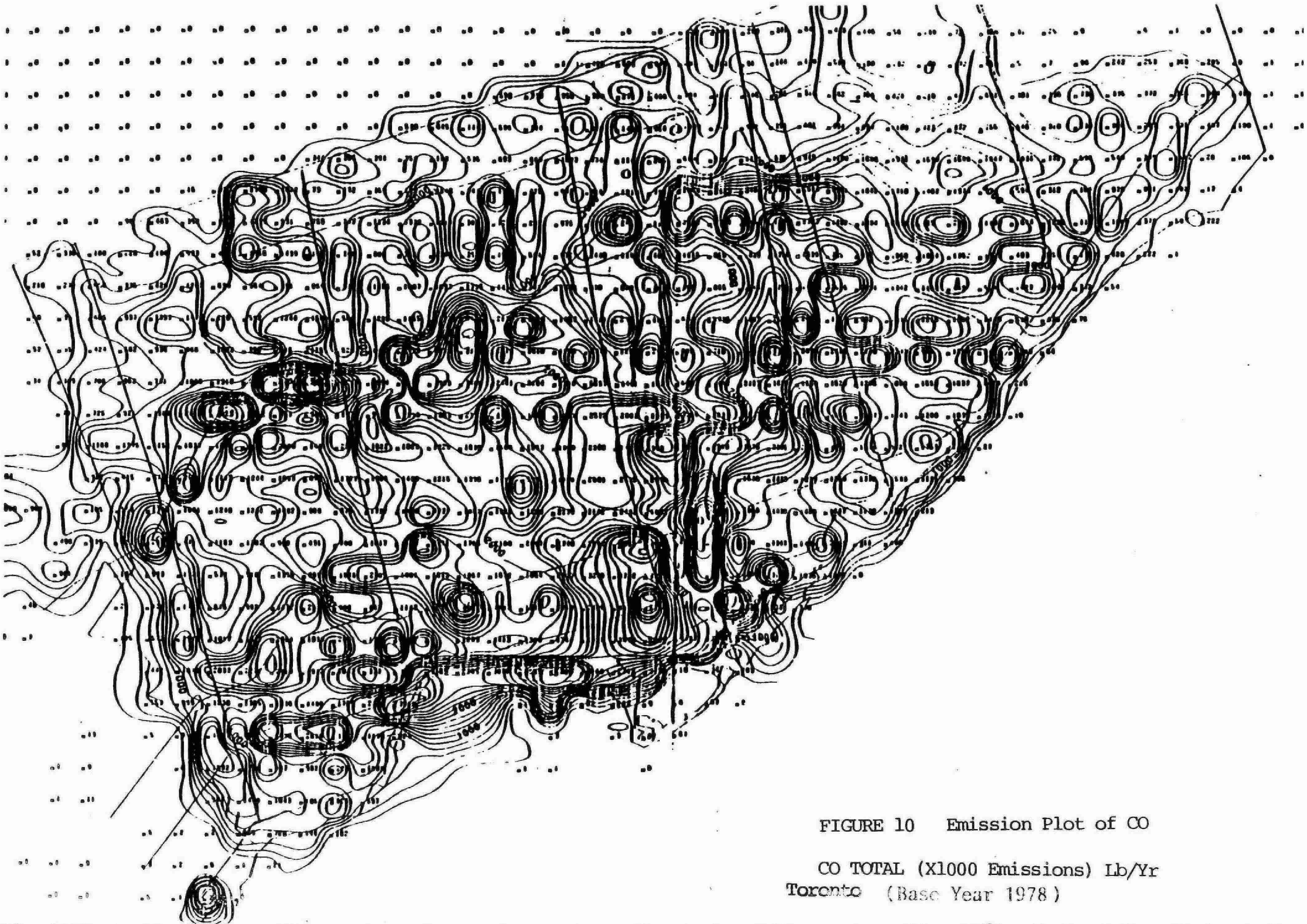


FIGURE 10 Emission Plot of CO

CO TOTAL (X1000 Emissions) Lb/Yr
Toronto (Base Year 1978)

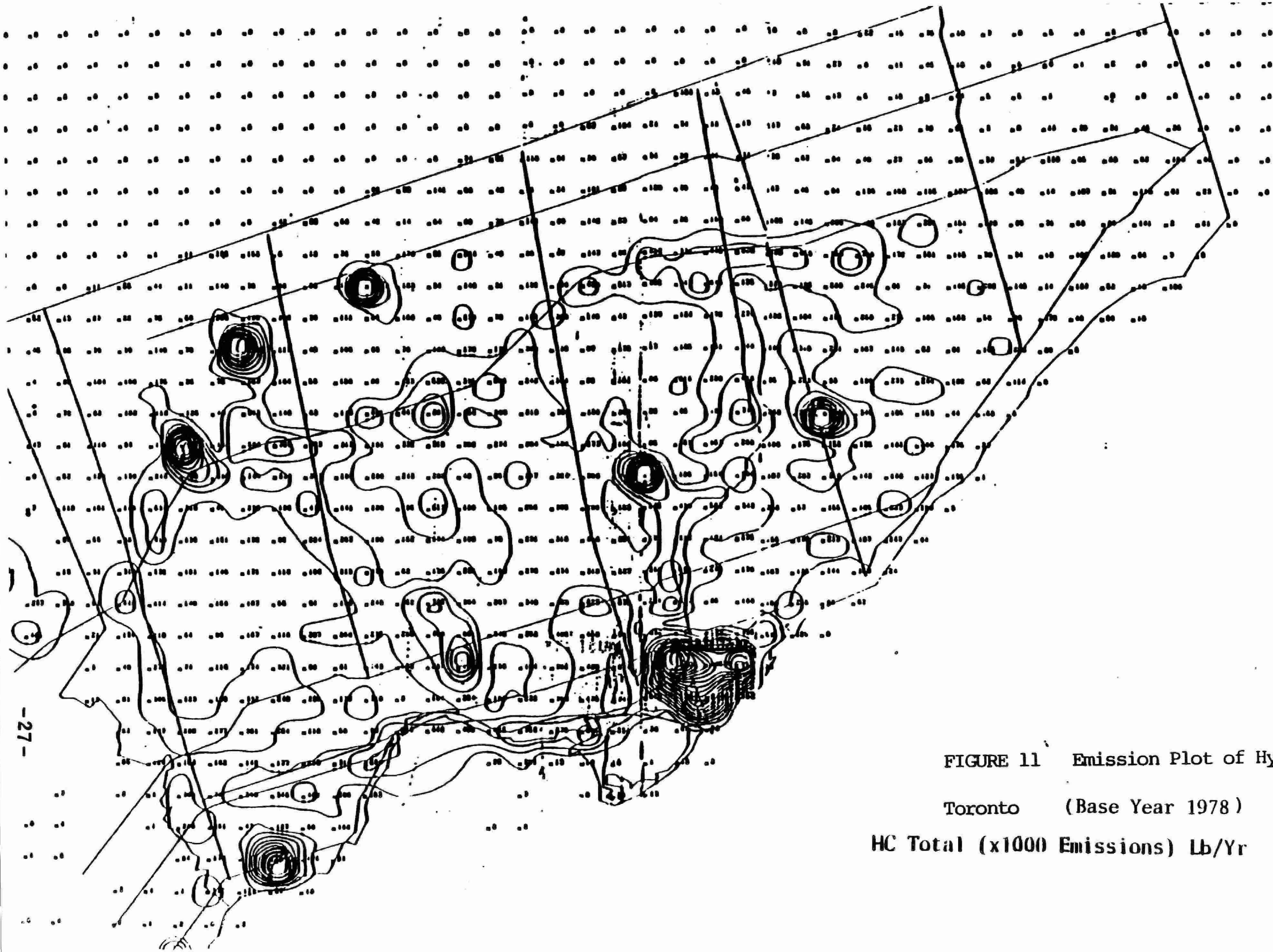


FIGURE 11 Emission Plot of Hydrocarbons

Toronto (Base Year 1978)

HC Total (x1000 Emissions) Lb/Yr

3.3.4 Problems Encountered in the Identification of Sources

In order to provide current emission information for the design of the monitoring network, a review of the 1974 inventory was performed. Due to manpower and time constraints, no attempt was made to update emission quantities.

However, nineteen (19) of the 153 (approximately 12%) major point sources on the 1974 listing were either shut down or no longer considered major. They have been deleted from the inventory. A scan of the 1974-1983 UP-12 Approval forms yielded 75 point sources, of which 18 were considered major and added to the inventory.

The UP-12 Approval forms, however, serve only to identify a potential major emission source and as designed, cannot be used readily for the updating of the inventory. Another problem with the 1974 inventory was that the accuracy of some of the emission data was questionnable. In order to update the data properly, a major in-depth survey of all the major sources is needed.

3.3.5 Complaints

Central Region received approximately 2600 complaints in 1984 for Metropolitan Toronto alone. Most of them were odour related. The distribution of complaints provides information on areas with potential air pollution problems.

Figure 12 shows the location of complaints in Metropolitan Toronto for the period January-April, 1984. Although the distribution was spread over the Metro area, two heavy clusters were observed. They were the two high profile areas of Junction Triangle and South Riverdale.

3.4 LAND USE AND SOCIAL PROFILE

3.4.1 General Considerations

A general land use map of Metropolitan Toronto was used to help identify suitable areas for locating the monitoring stations. Suitable areas included most residential, institutional and public buildings, open space, and the downtown commercial core.

Unsuitable areas included most industrial, traffic corridors, and valley lands. Also, major point sources and significant line sources were avoided.

Population and social profile were considered in the selection of AQI monitoring stations. Statistics Canada data on population density (population/km^2) by census tract was used to determine the areas of densest population. The higher the population density in an area (see Figure 13) [24] the more desirable it is to locate a monitoring site as the air quality measured will be meaningful to a greater proportion of the population.

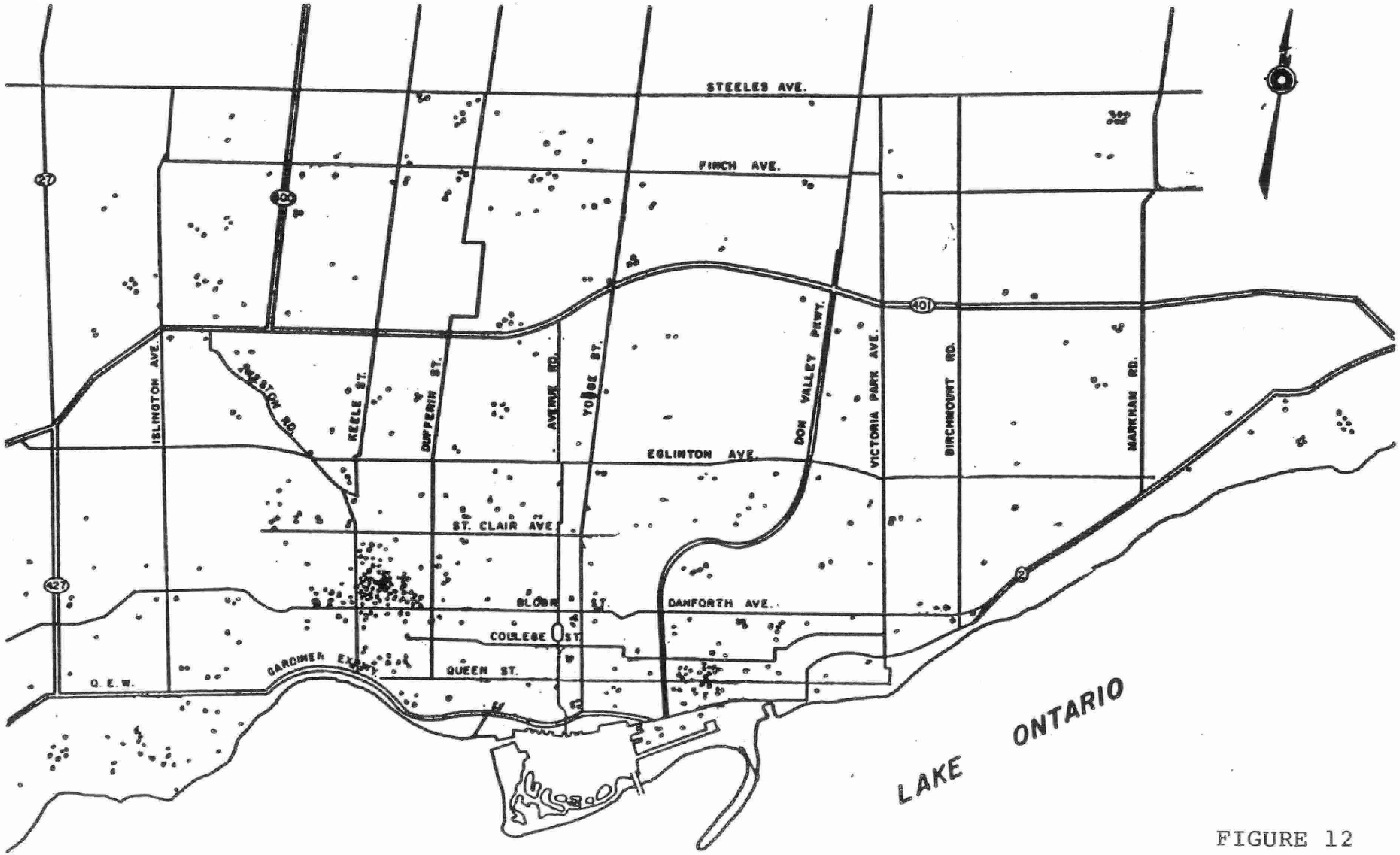
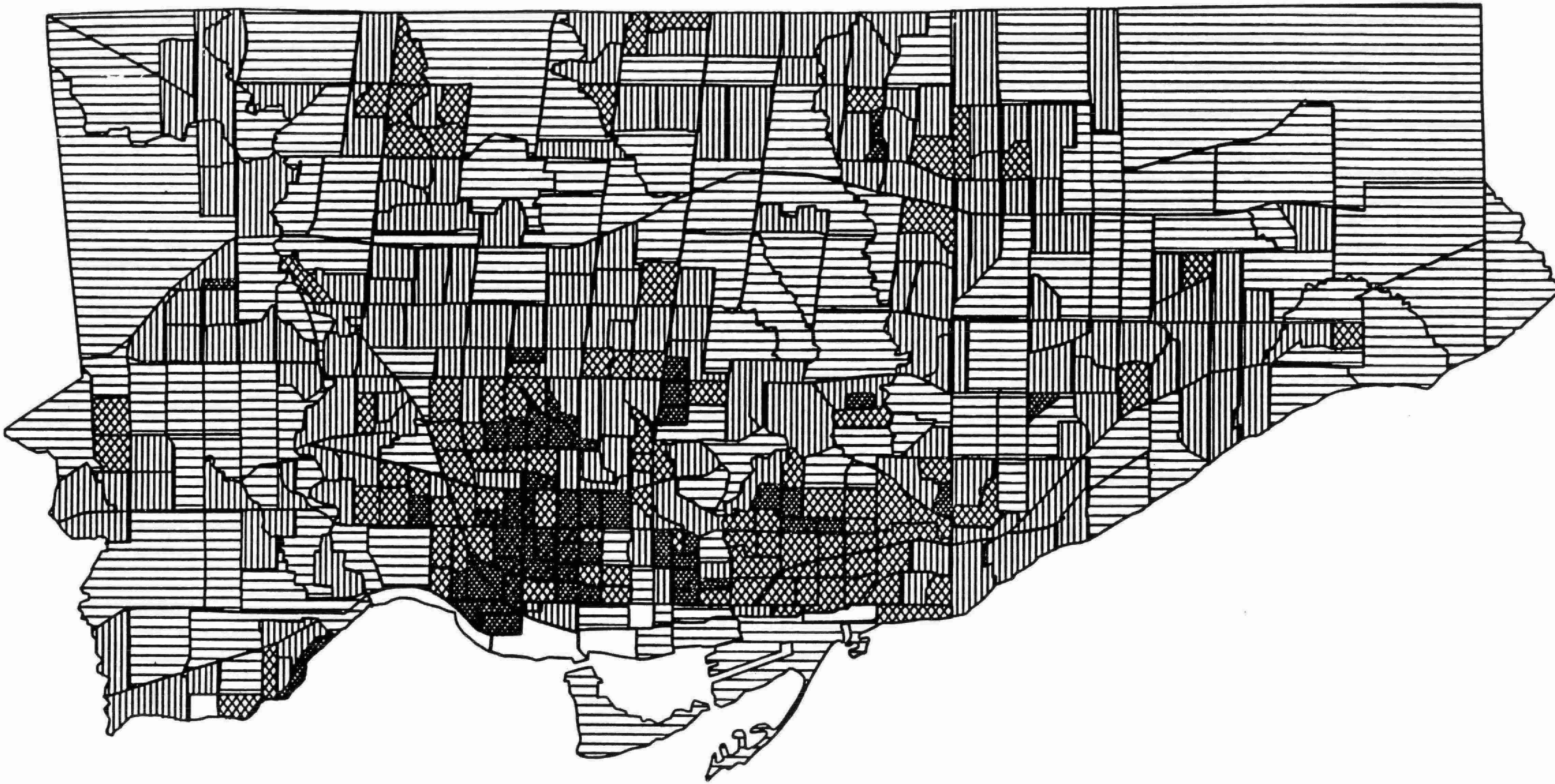


FIGURE 12

Distribution of Complaints in Metropolitan Toronto: January to April, 1984.

FIGURE 13 **POPULATION DENSITY PER SQUARE KILOMETER, 1981**



LEGEND: DENSITY

LESS THAN 100	100 - 2,999
3,000 - 5,999	6,000 - 9,999
10,000 AND OVER	

The sensitive portion of the population can be identified using the maps in Figure 14. [24] The age groups 0-5 and over 65 are considered sensitive receptors since they are more susceptible to adverse air pollution effects.

The socio-economic aspects should also be considered and were discussed in the previous section (Section 3.2.3).

3.4.2 Preparation for Site Selection Procedure

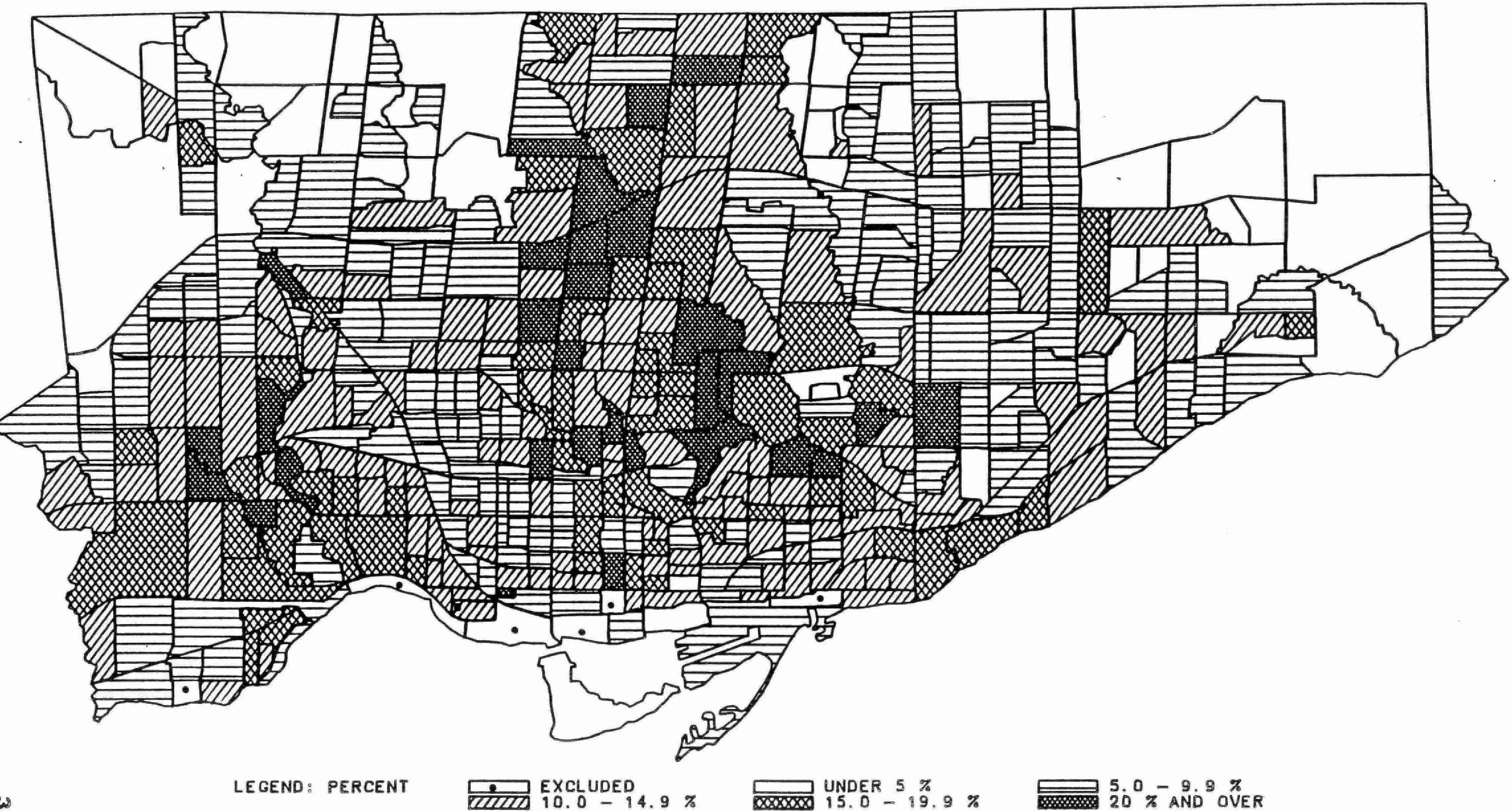
An overlay technique was used to determine prospective areas within which monitoring stations might be located. The general land use map was used as the base map. On a clear acetate overlay, population density over 6,000/km^2 was marked for all of Metropolitan Toronto. Outside the City of Toronto, population density between 3,000 and 5,999/km^2 was also marked to provide better definition of candidate areas.

On other overlays, areas with high proportions of sensitive populations were highlighted: areas where over 10% of the population were 0 to 5 years of age and over 20% of the population were over 65. Where the overlay areas coincided with areas of suitable land use, candidate areas were identified.

An overlay of unsuitable land uses was then used to subtract less desirable areas. The areas remaining were considered generally acceptable for the location of monitoring stations but in need of further consideration and refinement.

FIGURE 14a **PERCENTAGE OF POPULATION 0-5 YEARS, 1981**

FIGURE 14b PERCENTAGE OF POPULATION 65 YEARS AND OVER, 1981



4.0 SITE SELECTION PROCEDURES AND CRITERIA

Section 3 has discussed at length the first two steps in network design- the definition of objectives and the interpretation of various background information. This section deals with the selection of candidate sites and the consideration of the special characteristics of each classical pollutant.

4.1 GENERAL PRINCIPLES

Common practices in the design of air monitoring networks before 1969 were summarized in a survey by Yamada [45]. One of the conclusions was the need for standardization of location and design of air monitoring stations. Since then, guidelines on siting stations were produced by U.S. EPA (1971) [6] and (1975) [5]. Site selection procedures and criteria for specific pollutants such as SO_2, CO, photochemical pollutants and particulate matter were produced by U.S. EPA (1977) [11], (1975) [13], (1978) [14], and (1983) [8], respectively.

4.1.1 Estimation of Network Size

Network size is one of the parameters that must be decided early in the planning stage. The number of monitoring stations required depends primarily on the current air quality, its variability and the size of the study region. The network size must be adequate to allow definition of areas where ambient concentrations may be expected to exceed air quality standards.

An approximation of the number of stations needed may be obtained from Figure 15, in which the number is shown as a function of total population. [6] Thus Metropolitan Toronto with three million inhabitants may be well served by 8 to 11 stations equipped with continuous monitors.

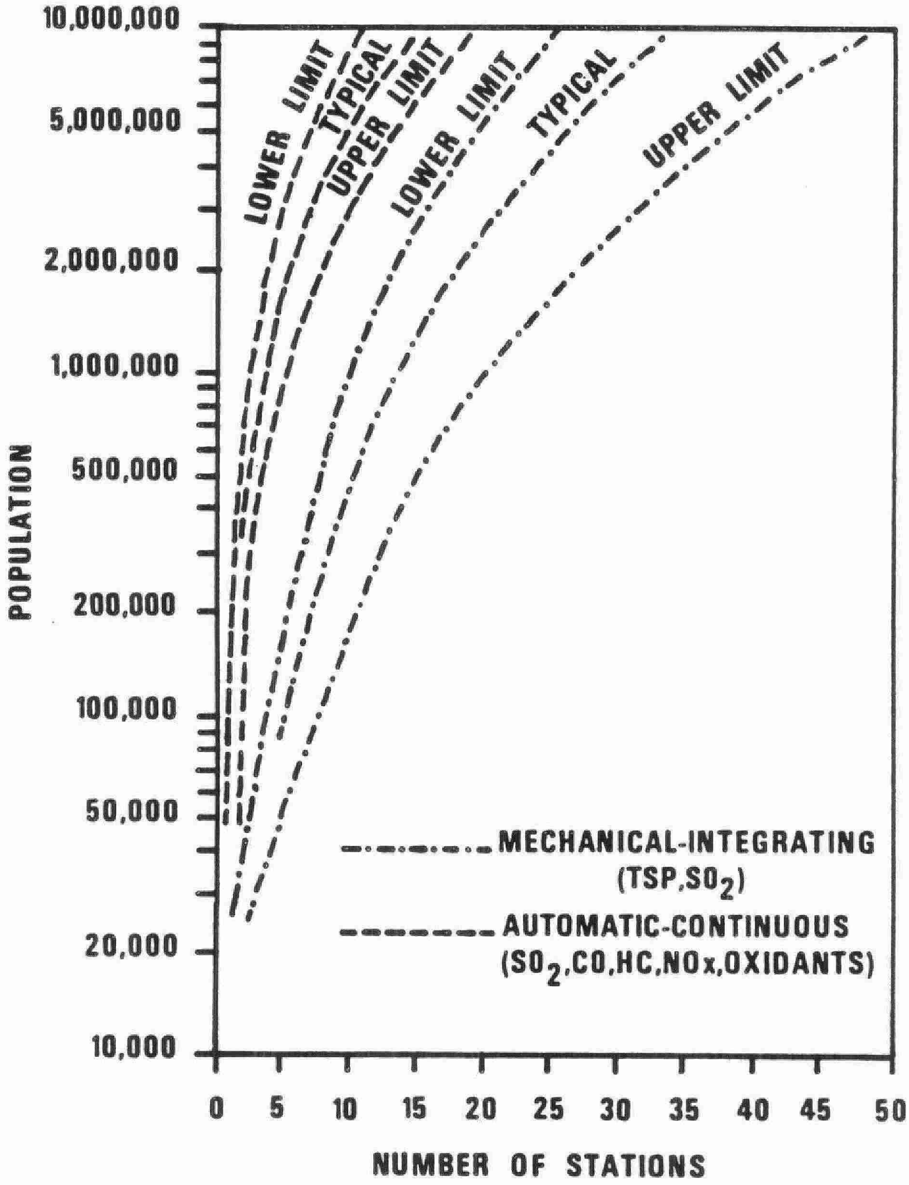


Figure 15 Number of stations per air quality control region as a function of population

Although population is a good index to network size, there are other factors which have to be considered:

a) Despite the fact that people are admitted polluters, their distribution and number may not reflect the distribution and strengths of problem pollutants. [6] Therefore, more direct factors such as emission dispersal patterns should be examined.

b) Political boundaries are a constraint. Each of the six local municipalities within Metro meets the AQI criterion whereby an Index will be issued for each community with a population of 100,000 or more.

c) High profile areas cannot be overlooked. Two areas of current environmental concerns in Toronto are Junction Triangle and South Riverdale. Air quality assessment and modeling studies for these areas have been documented in the mid-1970's [40], [42].

4.1.2 Selection of Monitoring Sites

The selection of monitoring sites involves decisions regarding a) the distribution of samplers within the network, i.e. candidate areas; and b) specific sites for each station.

The first decision requires consideration of monitoring objectives, overall pollution patterns, and the need for jurisdictional coverage. The second is based upon the representativeness of the area and other practical aspects such as power supply, security and so forth (See Section 5).

In short, the selection of a specific monitoring site requires four major steps [14]:

a) Identify the purpose to be served by the monitoring.

b) Identify the monitoring site type(s) that will best serve the purpose.

c) Identify the general locations where the monitoring sites should be placed.

d) Identify specific monitoring sites.

In order to simplify the site selection process, the procedures can be summarized in a schematic diagram. Figure 16 is a flow chart [23] showing the general requirements for selecting an urban neighbourhood site. Once the background materials have been gathered, the monitoring objectives defined, and the number of station estimated, guidelines such as the following must be considered:

1. The priority area is the zone of higher than average pollutant concentration.

2. Close attention should be given to densely populated areas, especially when they are in the vicinity of heavy pollution.

3. The AQI should be representative for a significant portion of the population.

4. There should be a minimum of one station in each of the six municipalities.

5. Future expansion of the network may be considered in areas of projected growth, eg. Scarborough North.

6. Existing monitoring station(s) may be integrated into the proposed network to provide continuity of air quality information, e.g. API station in downtown Toronto.

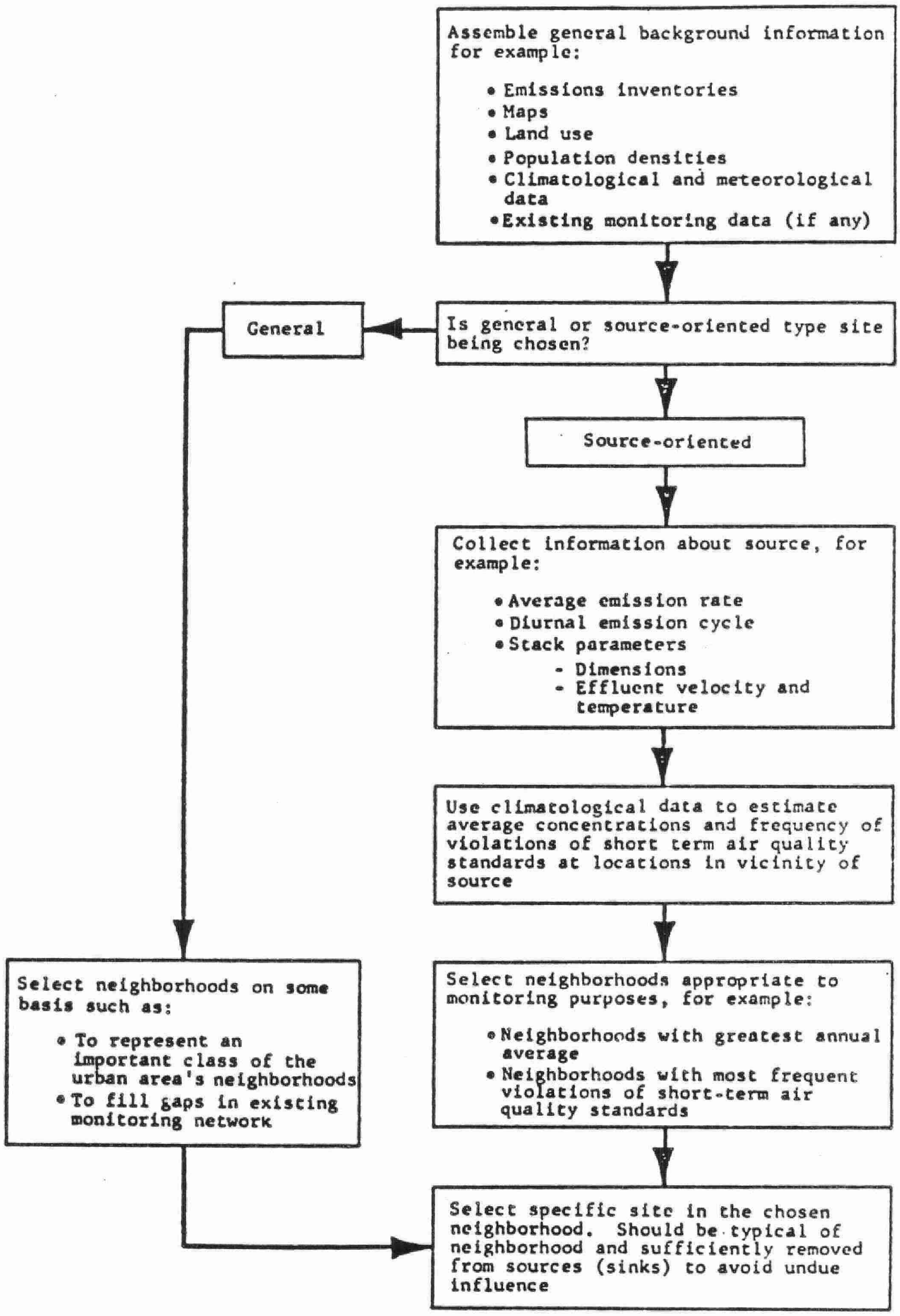


FIGURE 16 GENERAL PROCEDURE FOR LOCATING NEIGHBORHOOD MONITORING SITES

7. More than one sampling location may be required for certain municipalities e.g. City of Toronto, Etobicoke, and North York due to their large geographical areas, topographical effects such as valleys, and meteorological factors such as the lake breeze effect.

8. Special consideration should be given to the high profile areas such as the Junction Triangle and South Riverdale (located in the west and east end of the City of Toronto, respectively).

9. Air quality data should be available to represent all portions of the Metropolitan area, including a good mixture of land uses.

After all the candidate areas are marked on a base map (see Section 3.4), field trips to the potential sites can be made. An elimination process can begin by taking into account all the practical aspects of monitoring such as electrical power, accessibility and so forth. The final task is to document fully the characteristics of the specific sampling station sites.

4.2 SPECIAL CHARACTERISTICS

The guidelines presented in the previous section (4.1.2) are intended to help design a network in which numerous pollutants can be monitored. It is likely that common sites, although not necessarily ideal for each pollutant, may be chosen to give adequate coverage for all the standard pollutants. Due to the special characteristics of each of these pollutants, they are looked at individually.

4.2.1 Sulphur Dioxide (SO_2)

Sulphur dioxide is a heavy, pungent, colourless gas which has been associated with human respiratory illness, vegetation damage and the weathering of materials. It is the major sulphur oxide produced in the burning of sulphur-containing fuels.

In Toronto, power generating stations contribute more than 60% of the annual SO_2 emission. Lakeview G.S. an Hearn G.S. are the two major sources. The latter was decommisioned in 1983 and future use of the station is uncertain.

The general network configuration for SO_2 usually displays a rather uniform distribution over the built-up area with a decreasing density in areas farther from the urban core. The primary goals of SO_2 monitoring are all relatively well-served by such a population-oriented network with a typical site-to-site distance of at least 2-4 kilometers. [5]

One of the complications is the common presence of large point sources of SO_2. Provisions have to be made to include stations oriented toward determining the impacts of these sources. Ideally, such stations can be incorporated into the basic network; otherwise additional instruments/stations may be required.

As discussed in the previous section (4.1.2), a flow diagram can be drawn to simplify the site selection process. Figure 17 shows the recommended procedure for locating the three kinds of general-level, neighbourhood-scale stations. [11] First, the monitoring objective is chosen. This step is followed by the preparation of background information and the site selection process itself.

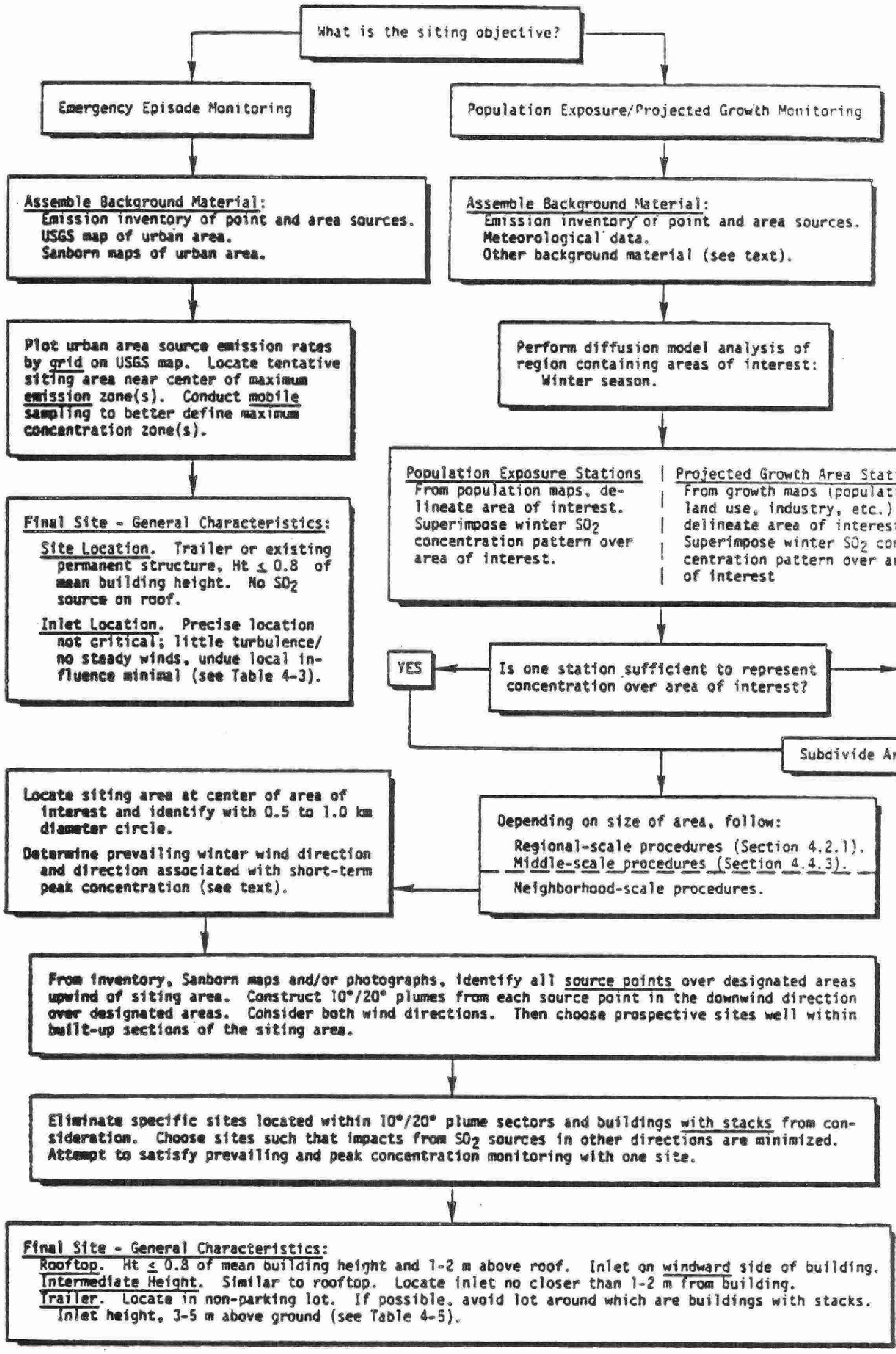


FIGURE 17 Flow chart showing procedures for locating general-level neighborhood SO_2 monitoring stations

4.2.2 Carbon Monoxide (CO)

Carbon monoxide is produced during the incomplete combustion of hydrocarbon fuels. The effects of excessive CO can be hazardous to people with heart disease and respiratory disorders such as emphysema. Automotive sources account for over 90% of all CO emissions in Toronto.

Unlike SO_2, the configuration of a typical CO network is neither well-defined nor adequate. The design process is complicated by the extreme sensitivity of the measured levels to the exact placement of the inlet probe. The fact that motor vehicles constitute the largest urban source of CO also means that most CO emissions occur near ground level along roadways.

This special characteristic of CO results in very large concentration gradients near ground level (Figure 18) [13]. It shows that concentrations at 3 meters above a downtown street can change by several parts per million (ppm) over distances of only a few tens of meters.

In contrast to some other pollutants, the CO sources and the public (or the monitoring station) can be very close to each other, resulting in little dilution of CO in the exposure area. This complicates the problem of devising methods for taking measurements that are more representative, whatever the purposes may be.

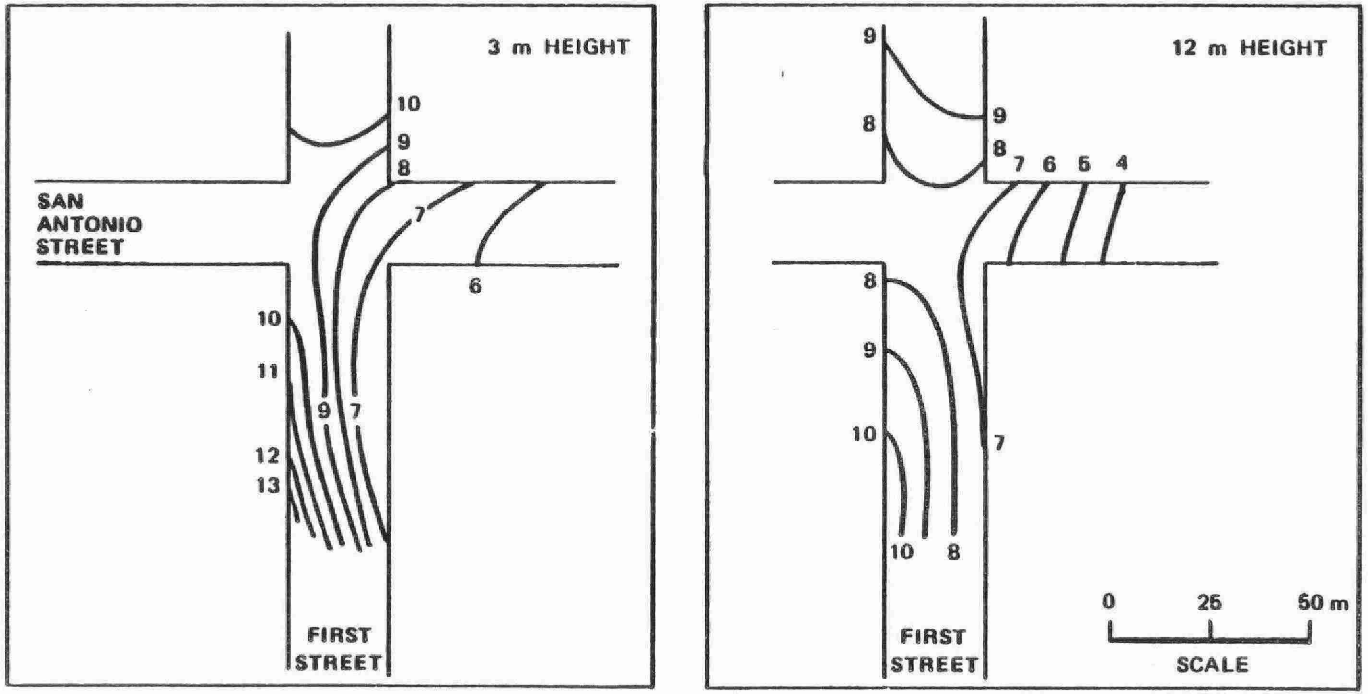


FIGURE 18 MEASURED HOUR-AVERAGE CO PATTERNS AT TWO HEIGHTS FOR A SAN JOSE, CALIFORNIA INTERSECTION (DURING LATE AFTERNOON ON 11 DECEMBER 1970)

However, it is recommended [5] that the overall CO network configuration should involve the following station types:

a) Street canyon - peak and average concentration;

b) Neighbourhood - peak and average concentration;

c) Traffic corridors; and,

d) Background.

While the proposed AQI stations cover mostly the neighbourhood scale of representation, the CO network will be complemented by other existing street canyon/ traffic corridor stations such as the Yonge/Gerrard site in the downtown core. Figure 19 illustrates the site selection procedure for CO monitors. [13]

4.2.3 Oxides of Nitrogen (NOx)

The oxides of nitrogen is the sum of nitric oxide (NO) and nitrogen dioxide (NO_2). Nitric oxide can be formed by the high-temperature combustion of fossil fuels such as in automobile engines, power plants, incinerators and many chemical processes. There is no evidence that ambient NO level has any direct adverse effect on health and welfare.

NO however, can in the presence of oxygen or hydrocarbons, be oxidized to nitrogen dioxide. NO_2 in high concentrations may have a detrimental effect on the respiratory system especially to those with chronic lung disease.

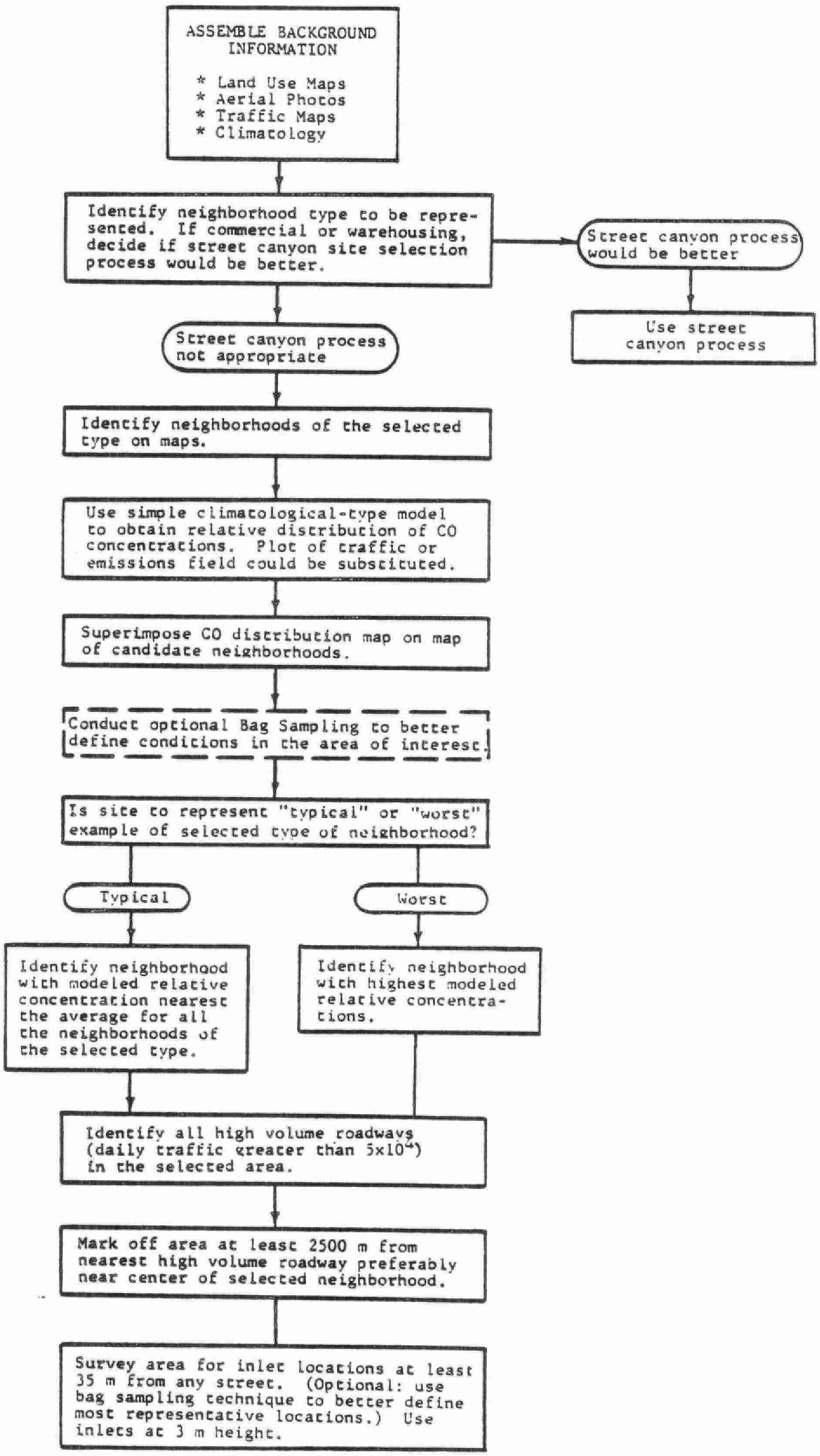


FIGURE 19 SCHEMATIC DIAGRAM OF A PROCEDURE FOR LOCATING NEIGHBORHOOD CO MONITORING STATIONS

The monitoring for NO is important, but the emphasis still remains on the criteria pollutant, NO_2. Figure 20 shows the procedure to select sites for neighbourhood scale NO_x monitoring. [14] After the background information is gathered, it must be decided whether the emphasis of monitoring will be on NO_x as a product (primarily NO_2) or as reactants in the photochemical process. Usually, general or product-oriented monitoring has been used to characterize population exposure.

Selecting neighbourhood scale, product-oriented monitoring sites for NO_2 begins with the definition of areas of major NO_x emissions and the most frequent wind directions for periods of photochemical activity. Emission inventory of NO_x and wind roses for hot summer months, such as the ones in Figure 21 can be used.[1] It has been suggested that temperatures above 20°C will serve to define the likely movement of the precursors under photochemically active conditions. [22]

Prospective siting areas will then be chosen downwind of the major source areas, usually a few kilometers. The measurements should be representative of a reasonably large, neighbourhood-sized area. Therefore, the monitoring station should be away from NO_x sources, either major point sources or traffic sources.

4.2.4 Hydrocarbons (Hc)

Hydrocarbons are emitted from both natural and man-made sources. The latter includes motor vehicles, gasoline storage tanks, and many industrial sources such as petroleum and chemical industries.

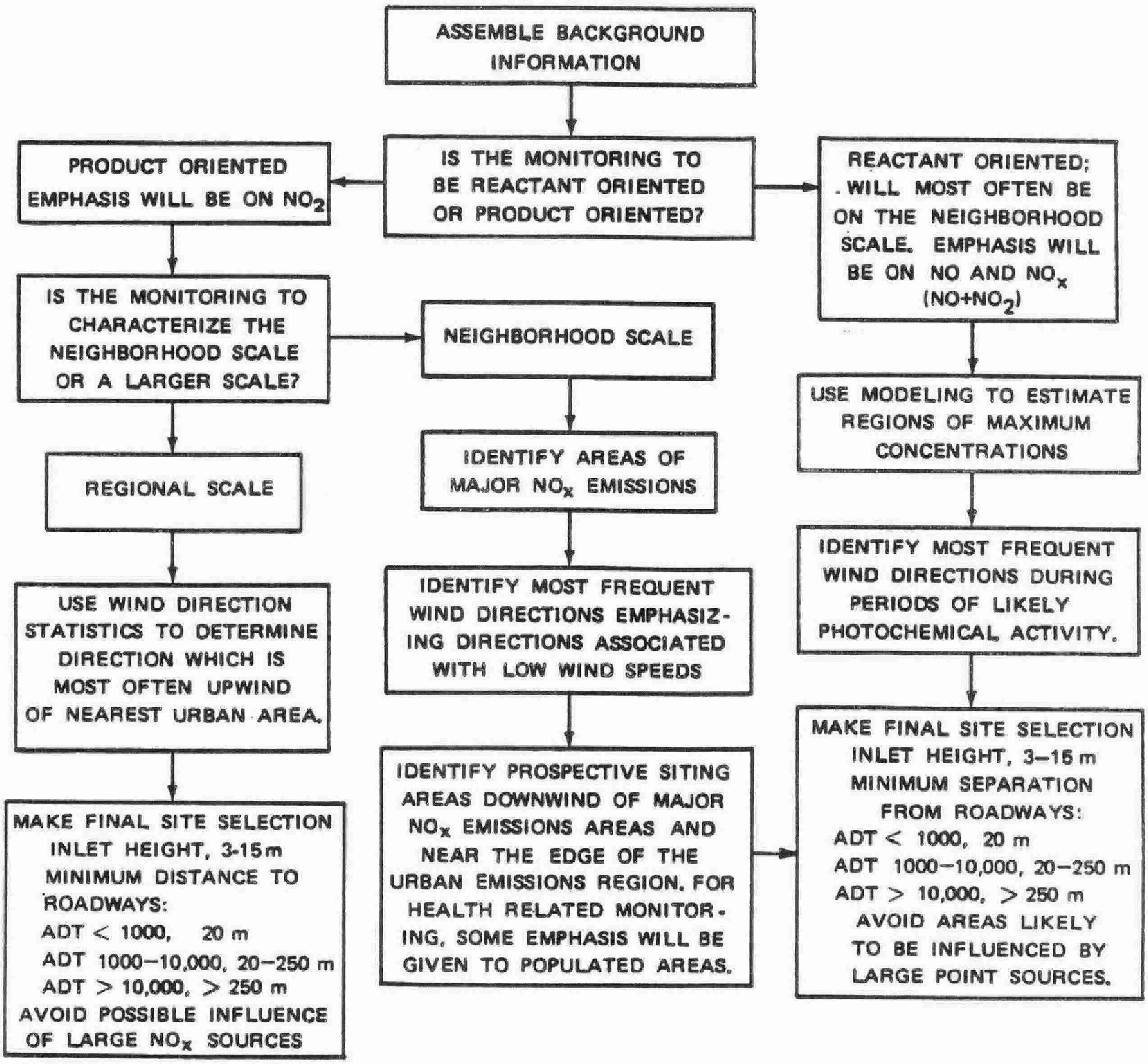


FIG. 20 SCHEMATIC DIAGRAM OF PROCEDURE FOR SELECTING NEIGHBORHOOD NO_x MONITORING SITES

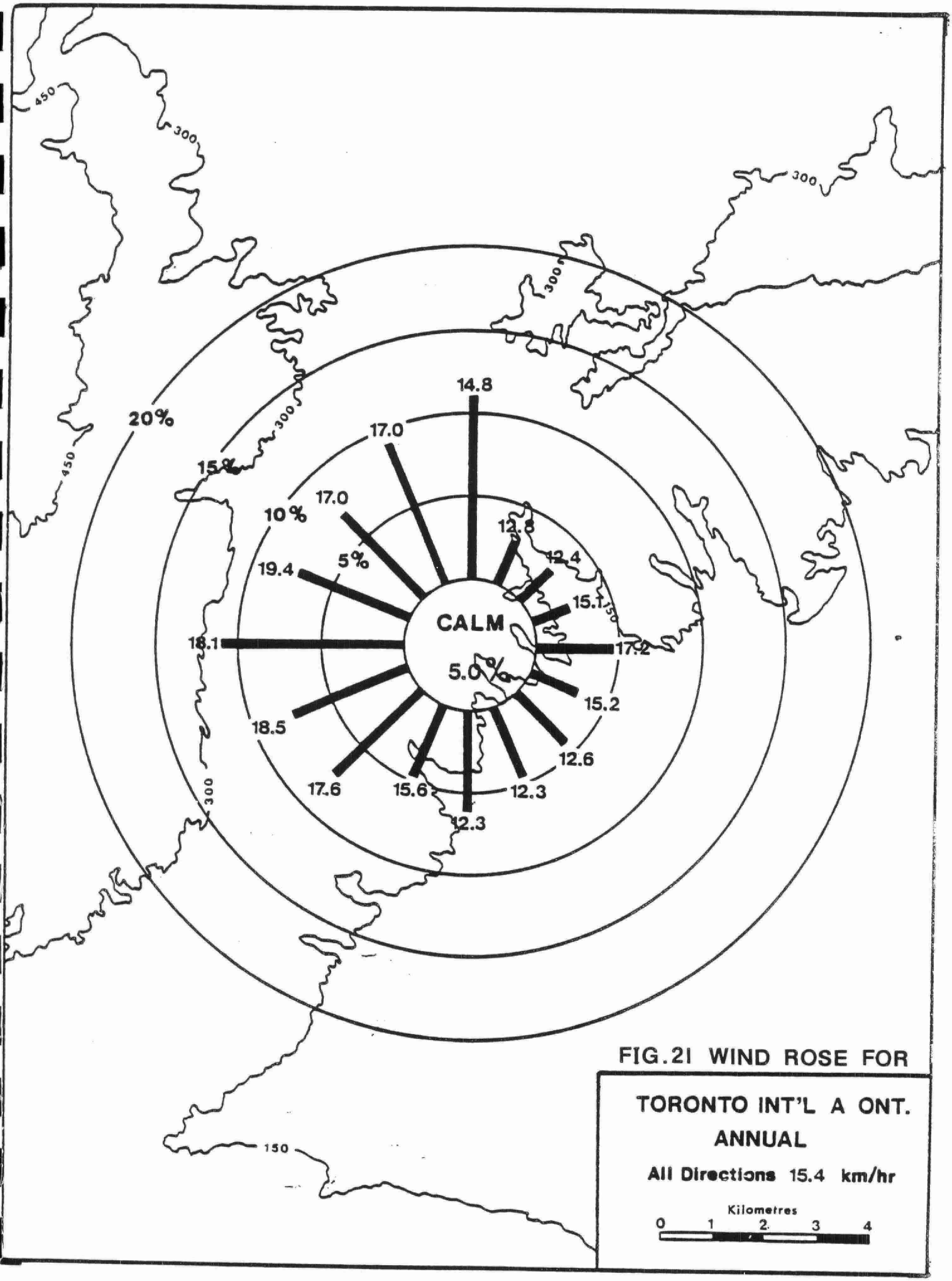


FIG. 21 WIND ROSE FOR

TORONTO INT'L A ONT.
ANNUAL

All Directions 15.4 km/hr

Total hydrocarbons are being monitored in Ontario. They include the methane and non-methane (reactive) hydrocarbons. It is the non-methane fraction that is of special interest as it reacts with nitrogen oxides in the presence of sufficient sunlight to form ozone and other oxidants (Figure 22). [14]

The monitoring of hydrocarbons will follow the same site selection principles used for nitrogen dioxide. The differences related to the pollutants' roles as reactants and as products are again essential. Although there is no criteria for hydrocarbons, their role as reactants is emphasized.

The step-by-step site selection process for non-methane hydrocarbons is presented in Figure 23. [14] Sensitive areas which are likely associated with high oxidant levels should be selected. Like the non-photochemical pollutants, the location for monitoring hydrocarbons should be chosen where nearby sources do not exert undue influence. They include ground level local sources such as gasoline stations, dry cleaners, surface coating operations and refineries.

4.2.5 Ozone (O_3)

Ozone is the most abundant oxidant, thus the terms ozone and oxidant are often used interchangeably. Ozone is not usually emitted directly by specific sources, but is rather a secondary pollutant that is formed from such reactants as reactive hydrocarbons and nitrogen oxides.

Adverse effects on human health and vegetation have been associated with high concentration of ozone. Ozone may irritate the lining of the nose and throat and hinder the functioning of the lungs. Plants and commercial

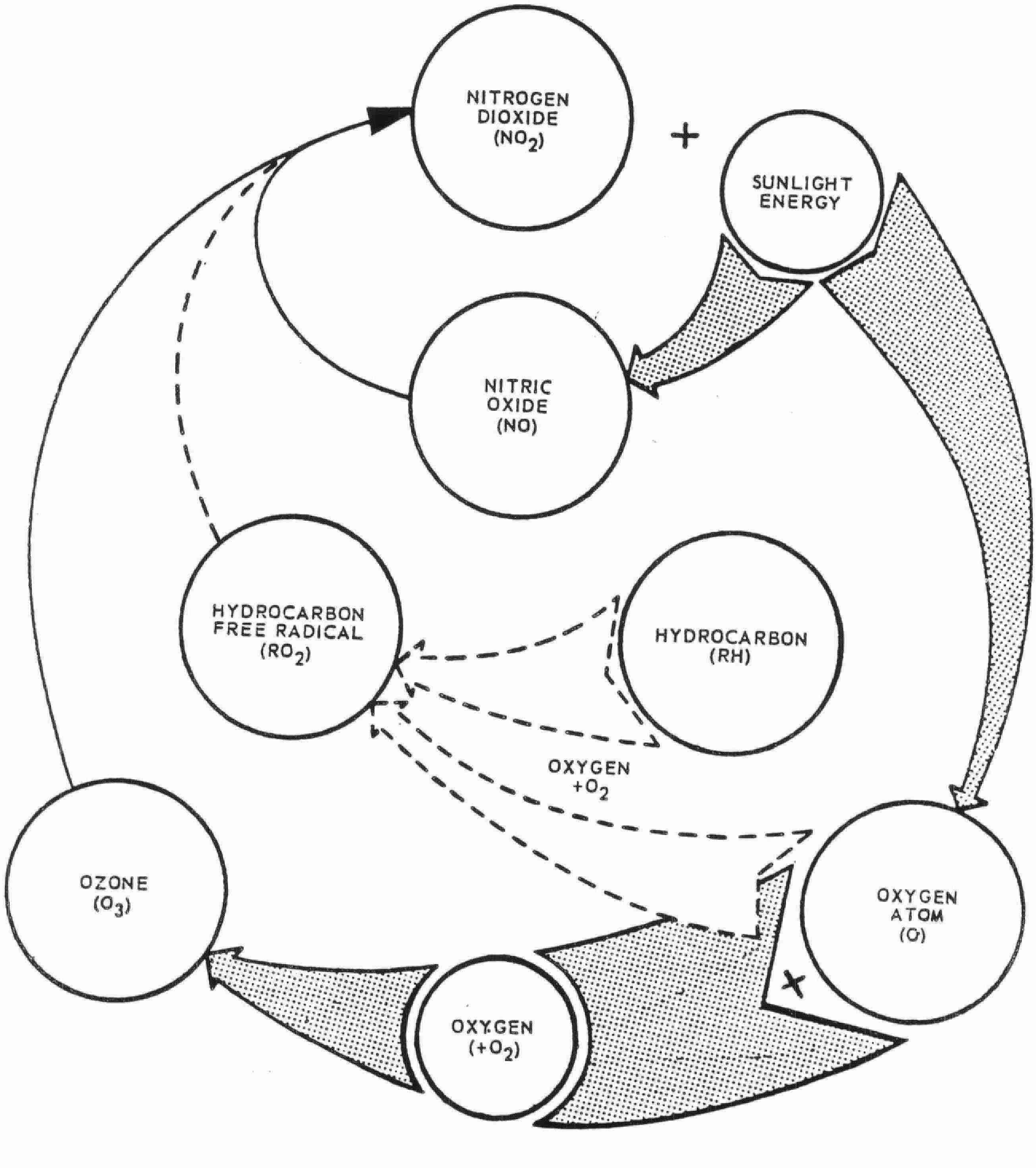


FIGURE 22: INTERACTION OF HYDROCARBONS WITH THE ATMOSPHERIC NITROGEN DIOXIDE PHOTOLYTIC CYCLE

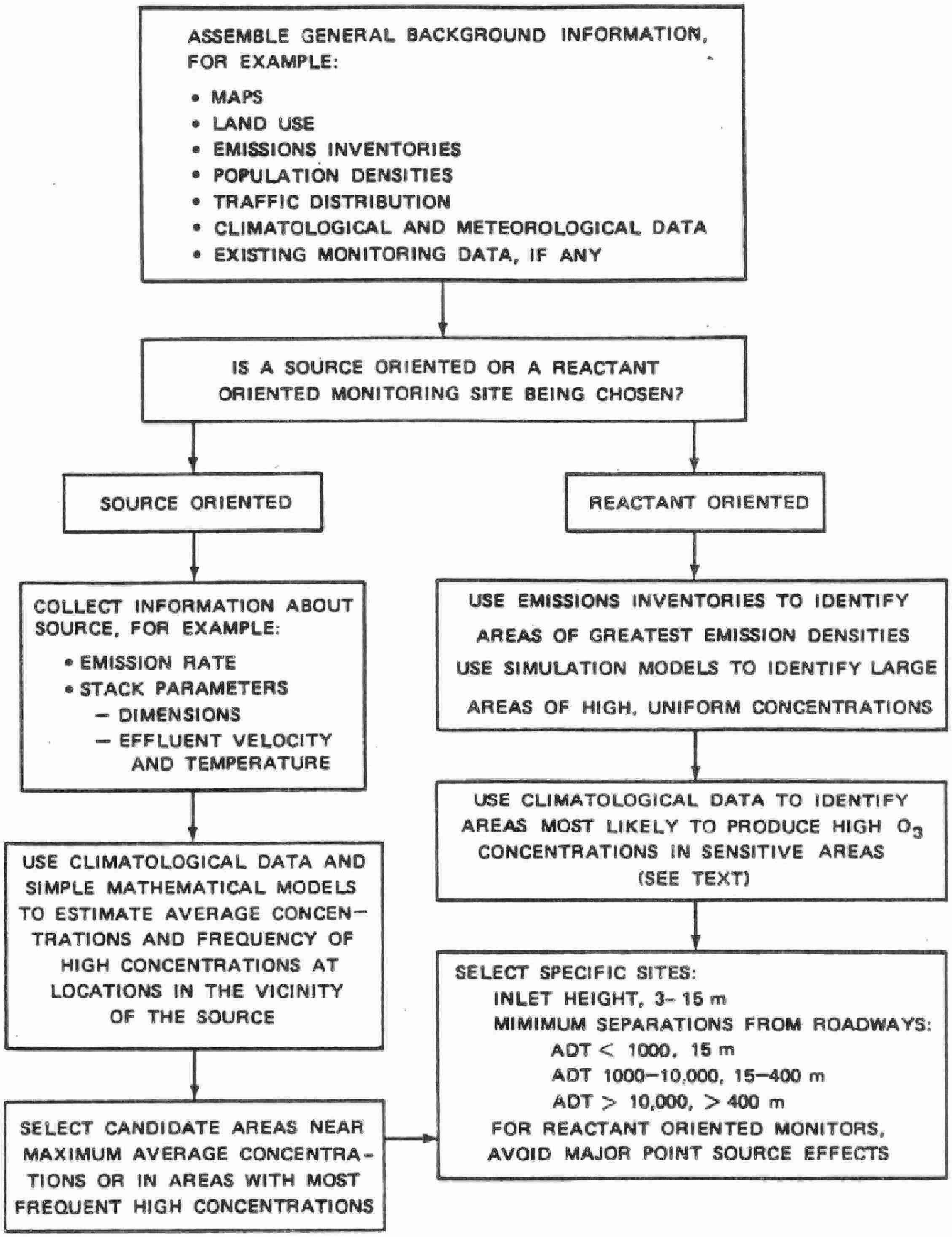


FIG. 23 SCHEMATIC DIAGRAM OF PROCEDURE FOR SELECTING NMHC MONITORING SITES

crops such as white bean and tobacco may be severely injured or killed by high ozone levels.

Since time is required for the photochemical reactions to produce ozone, the oxidant concentration tends to reach a peak later than the concentrations of such reactants as hydrocarbons and NO_x (Figure 24) [14].

Over the years, the long-range transport of ozone has been a major concern. Both the transport and formation aspects depend upon the intensity and duration of sunlight, temperature, and the emission and dilution processes affecting reactant concentrations in the photchemical cycle. The slow formation and transport of secondary pollutants tend to produce large spatial and temporal separations between the major sources and areas of high oxidant pollution.

As shown in Figure 25, candidate sites will be in reasonably homogeneous neighbourhoods within the urbanized areas.[14] They should also be away from the influence of major NO sources. Similar to the other photochemical pollutants, areas of high ozone concentrations can be defined using emission inventories and wind roses.

In an extensive metropolitan area like Toronto, the most likely locations for maximum ozone levels will be several kilometers beyond the down wind edge of the city. Therefore, the O_3 network has been and will continue to be supplemented by stations in satellite areas such as Stouffville. Within the Metro limits though, one of the basic objectives is to monitor areas of high ozone concentrations to which appreciable portions of the population are exposed.

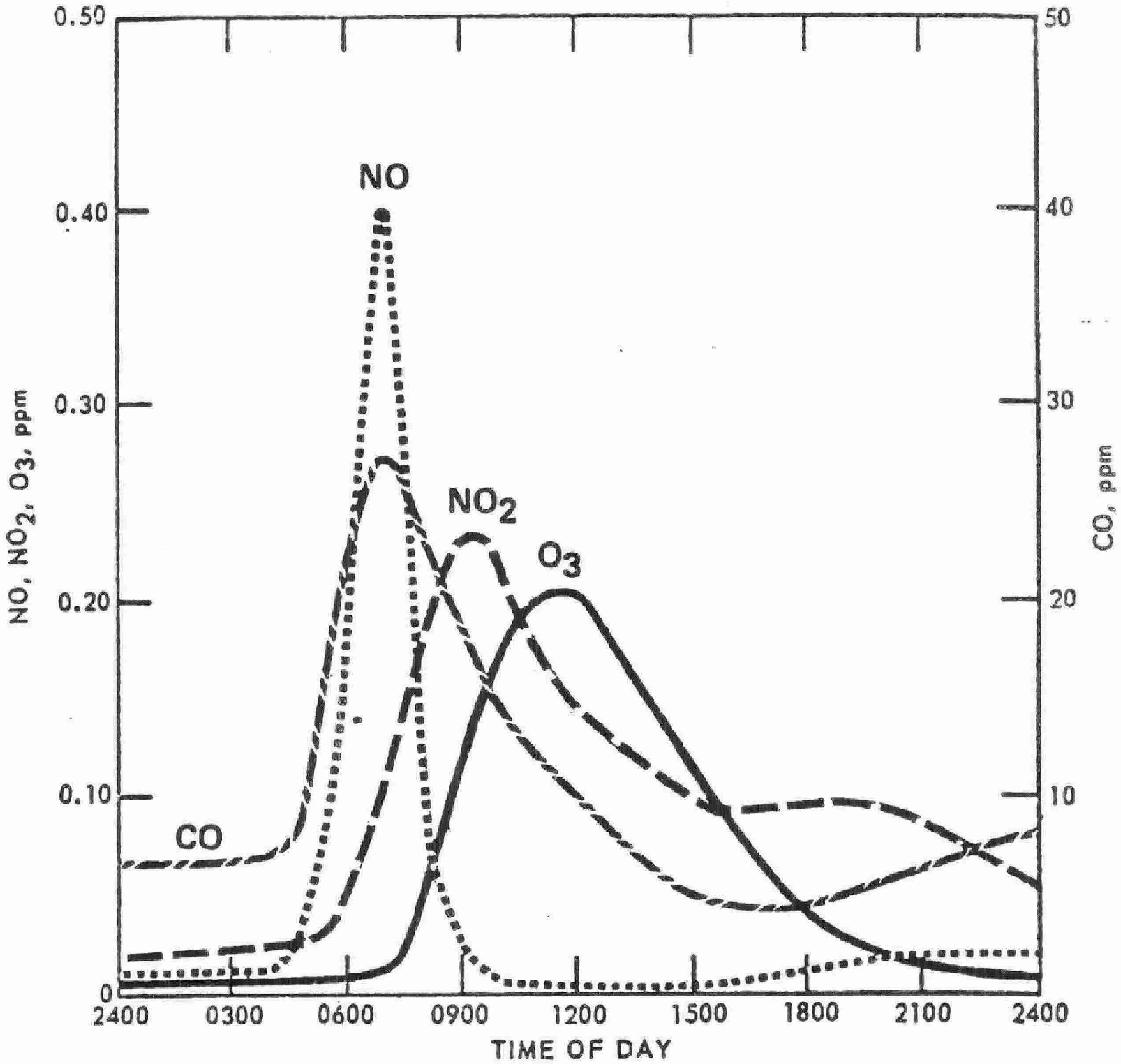


FIGURE 24: AN EXAMPLE OF DIURNAL CHANGES IN THE CONCENTRATIONS OF SELECTED POLLUTANTS IN LOS ANGELES

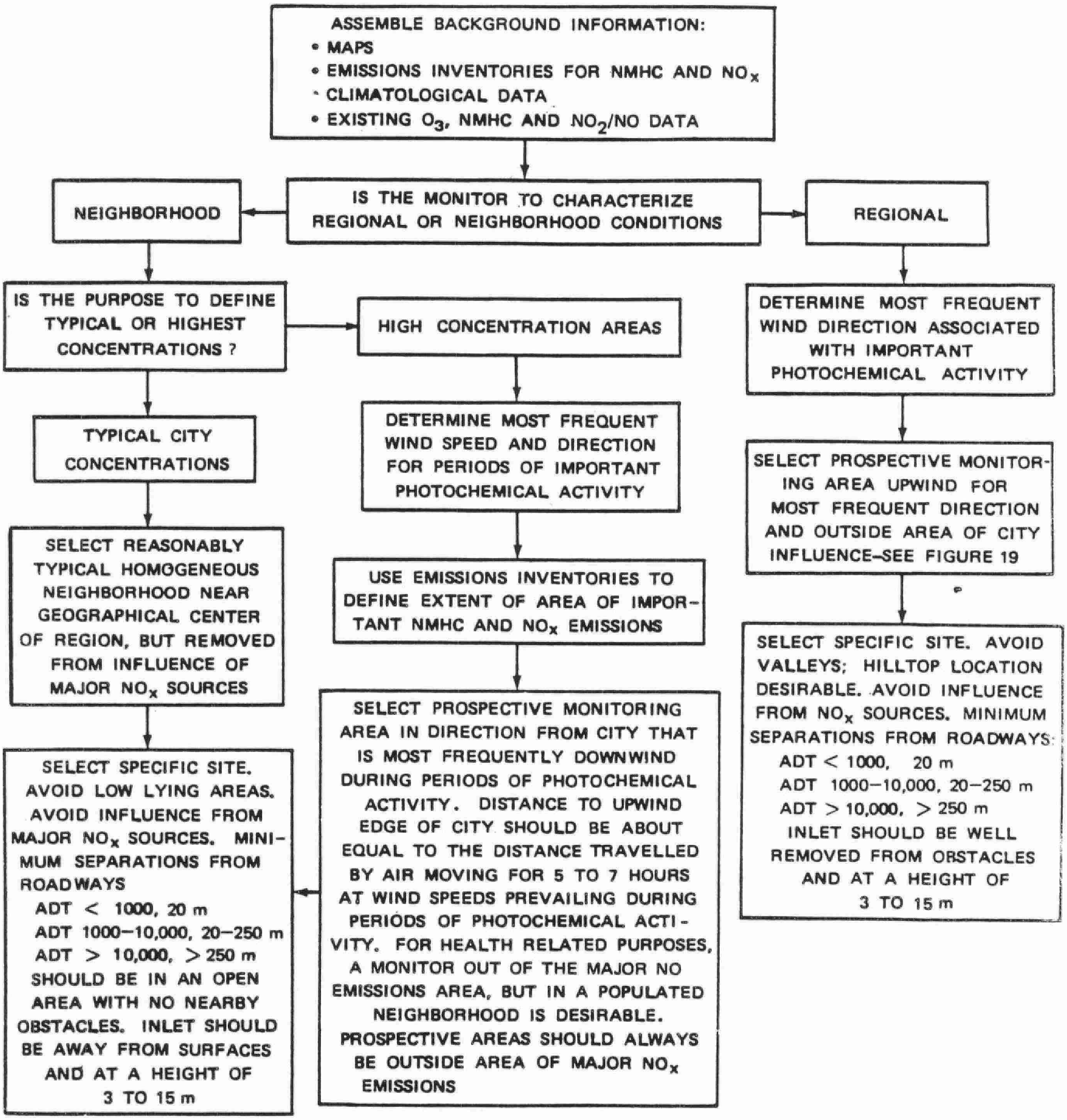


FIG. 25 SCHEMATIC DIAGRAM OF PROCEDURE FOR SELECTING OXIDANT MONITORING SITES

5.0 SITING CRITERIA FOR SPECIFIC STATION LOCATION

While the preceding section gave guidelines for the general distribution of sampling sites within the region, the selection of a specific station location is equally important. It is essential that the sampler be located to yield data representative of the location. The practical aspects of siting a station must also be considered.

5.1 GENERAL

There are general guidelines [6] that should be examined for specific site selection and inlet probe placement:

a) Uniformity in height above ground level is desirable for the entire network. Some exceptions may include the supplementary stations such as the street canyon CO monitor.

b) Constraints to airflow from any direction should be avoided by placing inlet probes at least 3 meters from buildings or other obstructions. Inlet probes should be placed to avoid influence of local sources.

c) An elevation of 3 to 6 meters is suggested as the most suitable for representative sampling, especially in residential areas. Placement above 3 meters prevents most reintrainment of particulates, as well as the direct influence of automobile exhaust.

Some of the other factors regarding the practical aspects of site selection are:

1. Security from vandalism.
2. Accessibility.
3. Power supply.
4. Use of land.
5. Cost of land rental.
6. No airflow restriction.
7. Free from point sources, stacks, etc.
8. Municipal involvement - land, security, public relations.

Problems of security and site accessibility cannot be ignored. Although cost is beyond the scope of this report, it has always been an intrinsic component in the design of a cost-effective air monitoring network. At present, the cost of a fully-equipped monitoring station is in the neighbourhood of $120,000. Equipment security is therefore very important.

Technicians will visit each site once to several times a week, and easy access is highly desirable. Safety is also a factor, especially in the winter. Moreover, each site will require electricity, and access to telephone lines for a telemetering link to the central computer facility.

Although the cost of land rental may be minimal, municipal land or facilities may not only reduce rental cost but also minimize vandalism. Open space may be preferable to avoid airflow obstructions. There should also be a minimum separation distance between the inlet probe and local sources.

The final important factor is the participation of the municipalities. With the local municipal cooperation, the implementation of the site selection process will run smoother. The municipalities may have suitable land available with easy access, and power supply. Also they may be aware of localized pollution problems.

In summary, the guidelines discussed in this section are general in nature. Special characteristics and probe siting criteria for each pollutant will be discussed in the next section. In order to meet the several specific siting criteria, some leeway must be allowed in the specific station location.

5.2 INLET PROBE SITING CRITERIA

Once a general area has been chosen, it is necessary to select a specific site for the station, and then within the confines of that choice to determine the precise location of the inlet probe. Ground-level versus roof-top stations have mostly been issues based on availability. However, the impact of the choice is more of a probe placement issue.

5.2.1 Sulphur Dioxide (SO_2)

The most desirable height for an SO_2 monitor inlet probe is near the breathing height. It must be located 3 to 15 meters above ground level. [12]

Since SO_2 is considered to be rather well mixed near the ground, either ground-level or roof-top sampling is

adequate. If the inlet probe is located on the roof (like most downtown core stations), it must be at least 1 meter from walls, penthouses and so forth. If the probe is on the side of the building, then it should be on the windward side of the building relative to the prevailing winter wind direction.

In addition, the inlet probe must be located more than 1 meter vertically or horizontally away from any supporting structure and also away from dirty, dusty areas. No minor sources of SO_2, including furnace and incineration flues, should be nearby. Trees should be more than 20 meters away.

Airflow must be unrestricted in three directions (270° around the probe). The predominant wind direction must be included in this 270° arc. The inlet probe must also be located away from obstacles and buildings. The distance between the obstacles and the probe have to be at least twice the height that the obstacle protrudes above the probe. A summary of the requirements for probe siting criteria is presented in Table 3. [12]

5.2.2 <u>Carbon Monoxide (CO)</u>

The probe siting criteria for CO greatly depends on the purpose of the monitoring, be it a street canyon or neighbourhood station. Because of the importance of measuring population exposure, air should be sampled at average breathing height. However, practical factors require that the inlet probe be higher.

For a street canyon or a microscale station, $3\pm1/2$ meters above ground is recommended. A minimum distance of 2 meters and a maximum 10 meters from the edge of the

Table 3 -Summary of probe siting criteria

Pollutant	Scale	Height above ground, meters	Distance from supporting structure, meters: Vertical	Distance from supporting structure, meters: Horizontal[a]	Other spacing criteria
TSP	All	2–15	—	>2	1. Should be >20 meters from trees. 2. Distance from sampler to obstacle, such as buildings, must be at least twice the height the obstacle protrudes above the sampler.[b] 3. Must have unrestricted airflow 270° around the sampler. 4. No furnace or incineration flues should be nearby.[c] 5. Must have minimum spacing from roads. This varies with height of monitor and spatial scale (see Figure 1).
SO_2	All	3–15	>1	>1	1. Should be >20 meters from trees 2. Distance from inlet probe to obstacle, such as buildings, must be at least twice the height the obstacle protrudes above the inlet probe.[b] 3. Must have unrestricted airflow 270° around the inlet probe, or 180° if probe is on the side of a building. 4. No furnace or incineration flues should be nearby.[c]
CO	Micro	$3 \pm \frac{1}{2}$	>1	>1	1. Must be >10 meters from intersection and should be at midblock location. 2. Must be 2–10 meters from edge of nearest traffic lane. 3. Must have unrestricted airflow 180° around the inlet probe.
	Middle, neighborhood	3–15	>1	>1	1. Must have unrestricted airflow 270° around the inlet probe, or 180° if probe is on the side of a building. 2. Spacing from roads varies with traffic (see Table 1).
O_3	All	3–15	>1	>1	1. Should be >20 meters from trees. 2. Distance from inlet probe to obstacle, such as buildings, must be at least twice the height the obstacle protrudes above the inlet probe. 3. Must have unrestricted airflow 270° around the inlet probe, or 180 if probe is on the side of a building. 4. Spacing from roads varies with traffic (see Table 2).
NO_2	All	3–15	>1	>1	1. Should be >20 meters from trees. 2. Distance from inlet probe to obstacle, such as buildings, must be at least twice the height the obstacle protrudes above the inlet probe.[b] 3. Must have unrestricted airflow 270° around the inlet probe, or 180° if probe is on the side of a building. 4. Spacing from roads varies with traffic (see Table 3).
Pb	Micro	2–7	—	>2	1. Should be >20 meters from trees. 2. Distance from sampler to obstacle, such as buildings, must be at least twice the height the obstacle protrudes above the sampler. 3. Must have unrestricted airflow 270° around the sampler. 4. No furnace or incineration flues should be nearby.[c] 5. Must be 5 to 15 meters from major roadway.
	Middle, neighborhood, urban, and regional.	2–15	—	>2	1 Should be >20 meters from trees 2 Distance from sampler to obstacle, such as buildings, must be at least twice the height the obstacle protrudes above the sampler. 3 Must have unrestricted airflow 270° around the sampler. 4. No furnace or incineration flues should be nearby.[c] 5. Spacing from roads varies with traffic (see Table 4).

[a] When probe is located on rooftop, this separation distance is in reference to walls, parapets, or penthouses located on the roof.
[b] Sites not meeting the criterion would be classified as middle scale (see text).
[c] Distance is dependent on height of furnace or incineration flue, type of fuel or waste burned, and quality of fuel (sulfur, ash, or lead content). This is to avoid undue influences from minor pollutant sources.

nearest traffic lane must be maintained. The inlet probe must be located at least 10 meters from a intersection and preferably at a midblock site.

It is also known that for peak CO sampling within street canyons, the side of the street which is opposite the side facing the rooftop-level wind will experience higher concentrations (see Figure 26).[5] Therefore, even a choice of the side of the street becomes a siting issue for locations where prevailing winds are significant.

For neighbourhood scale stations, the vertical concentration gradients are not as great as for the microscale stations. Hence, a less stringent height of 3 to 15 meters is allowable. In determining the minimum separation between a neighbourhood station and a specific line source, the presumption is made that measurements should not be unduly influenced by any one roadway.[12] Table 4 provides the required minimum separation distance.

Similar to SO_2, the inlet probe for CO must be located more than 1 meter from any supporting structure, vertically or horizontally. Airflow must be unrestricted in an arc of at least 270° around the probe. Significant spacing from obstruction should also be allowed. (See summary in Table 3).

5.2.3 Nitrogen Dioxide (NO_2)

NO_2 is considered fairly well mixed and somewhat uniform vertically, thus the inlet height is not a critical factor. It reflects in the 3 to 15 meters above ground required. This is a compromise between

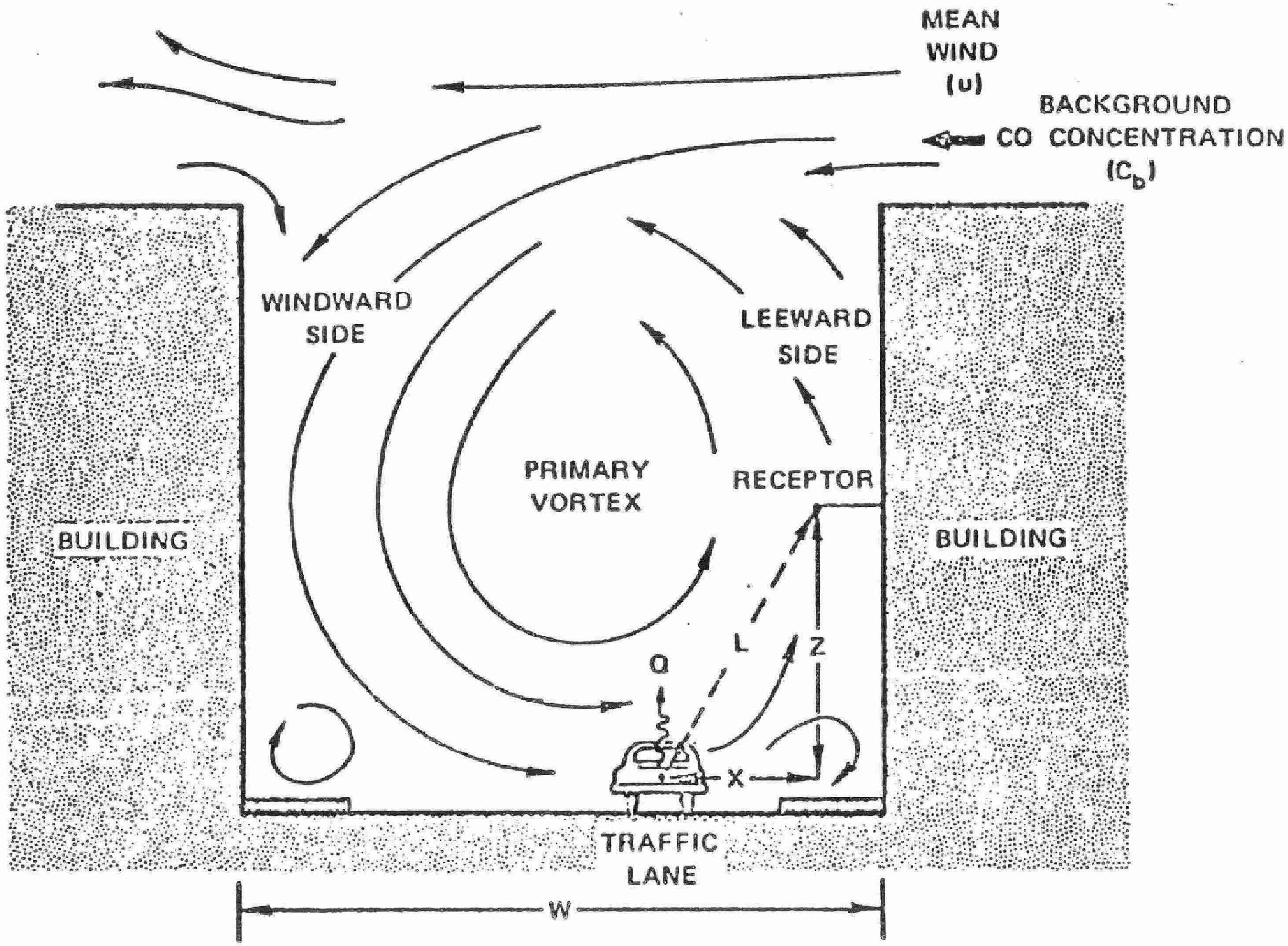


Figure 26 . Schematic of cross-street circulation in street canyon[7]

measuring in the breathing zone and security from vandalism, site availability, etc. Ground-level and roof-top sampling are both acceptable.

As in SO_2 and CO, there must be unrestricted airflow in three directions (270° arc). The probe has to be more than 1 meter away from any supporting structure in the vertical or horizontal direction. Trees and obstacles like building structures may possibly scavenge NO_2; hence the inlet probe must be well away from this kind of interference.

Like CO, spacing from roadways is important. The NO_2 sensor should be removed from nitrogen oxides sources to avoid the measurements being dominated by any one source and to allow time for conversion of NO emissions to NO_2. Table 5 presents the minimum separation distance between neighbourhood stations and roadways. [12] This distance should also be maintained between the inlet probe and any similar volume of automotive traffic such as parking lots.

The requirements for NO_2 probe siting criteria are summarized in Table 3.

5.2.4 Hydrocarbons (Hc)

As part of the photochemical process, the hydrocarbons site selection criteria are similar to those for NO_2. However, an elevated H_C sensor is preferred in the urban core so as to limit the influence of any single roadway and provide a more representative measurement of the area.

TABLE 4—MINIMUM SEPARATION DISTANCE BETWEEN NEIGHBORHOOD SCALE CO STATIONS AND ROADWAYS (EDGE OF NEAREST TRAFFIC LANE)

Roadway average daily traffic, vehicles per day	Minimum separation distance between stations and roadways, meters
<10,000	[1] >10
15,000	25
20,000	45
30,000	80
40,000	115
50,000	135
>60,000	>150

[1] Distances should be interpolated based on traffic flow.

TABLE 5—MINIMUM SEPARATION DISTANCE BETWEEN NEIGHBORHOOD AND URBAN SCALE NO_2 STATIONS* AND ROADWAYS (EDGE OF NEAREST TRAFFIC LANE)

Roadway average daily traffic, vehicles per day	Minimum separation distance between roadways and station, meters
<10,000	[1] >10
15,000	20
20,000	30
40,000	50
70,000	100
>110,000	>250

[1] Distances should be interpolated based on traffic flow.
* Applicable to O3 stations also.

When compared to the other photochemical pollutants, i.e., NO_2 and O_3, the effects of obstructions and nearby surfaces may not be as great for hydrocarbons.

Since hydrocarbons and NO_x should be monitored at the same site in order to provide the ratios of H_c to NO and NO_2, guidelines on the avoidance of obstacles should be followed. A height of 3 to 15 meters is recommended for hydrocarbons. This height range should be limited in order to allow comparisons of data collected at various stations to be made in such a way that data differences represent differences in the general pollutant concentration, rather than the effects of local sources and vertical gradients.

5.2.5 Ozone (O_3)

As with NO_2, the inlet probe for ozone monitors should be as close as possible to the breathing zone. A height of 3 to 15 meters above ground level is again required.

The scavenging effect of trees is greater for ozone than for SO_2, CO, and NO_2, and the probe must be located to avoid this effect. As shown in Table 3, the inlet should be located at least 20 meters from trees. Spacing from obstructions should follow the guidelines enumerated for the other pollutants.

It is essential to minimize interferences from nitric oxide (NO) sources since NO readily reacts with ozone. Special precautions should be taken not to locate O_3 sites within 100 meters of major arteries or large

parking areas due to the scavenging effect of NO emissions. [5]

The minimum separation distances between neighbourhood scale O_3 stations and roadways appear in Table 5. These distances are the same for both NO_2 and O_3.

5.3 SITE DOCUMENTATION

The documentation of air monitoring sites is an important and logical final stage in establishing the network. As time passes and data accumulates, it is easy to lose sight of the monitoring objectives of each sampling site. The classification of sites based on this documentation can also serve as a check that all stations satisfy the siting criteria.

Documentation usually begins with a site visit and photographs of the sampler from the four main compass points. The photographs show its immediate location and the broad area surrounding it. A sketch of the roof or area on which the sampler sits can be prepared, showing distances to wind-flow obstructions and their elevations. In addition, a map of the area within two kilometers of the sampler is often included, showing land uses and significant pollution sources.

In Appendix C, the site documentation for a NAPS [3] (National Air Pollution Surveillance) station in Toronto is presented.

6.0. RATIONALE AND SUPPORT DOCUMENTATION FOR SELECTION CRITERIA

The site selection and inlet placement criteria discussed in Section 4 and 5 are rather specific, particularly those regarding location parameters such as height of the inlet probe, proximities of interfering sources and so on. This section presents the rationale for some of the procedures and recommendations.

6.1 BACKGROUND

The logic behind the selection criteria and procedures are embodied in three basic steps:

a) Determining the general area suitable for monitoring.

b) Refining the location to minimize undue influences from nearby sources, including meteorological effects.

c) Placing the inlet probe in a location free of local interferences.

All three steps have been discussed in the previous two sections. In this section, the reasons behind these steps are given. Other factors pertaining to network design are also considered.

6.2 FACTORS AFFECTING SELECTION CRITERIA

6.2.1 Effects of Air Pollution Sources

All the proposed AQI stations were designed to represent large areas and significant portions of the population.

They were selected in areas of small gradients so that the monitoring results would not be affected by small changes in the location of the station.

This criterion will be met if no single source contributes disproportionately to the readings obtained at a certain site. The measurements should represent the sum of many small contributions from numerous individual sources.

In the case of CO, the influence of local sources is pronounced. Kinosian and Simeroth (1973) found that the annual, maximum hourly average CO concentration varied strongly with distance from the nearest traffic for nine Los Angeles area monitoring sites; their results are rather startling, as shown in Figure 27. [13]

EPA (1975) has used a simple model to confirm that nearby sources generally contribute a major portion of the observed CO concentration at a point. For neighbourhood type sites, the contributions from the nearest 2 km were found to account for 15 to 40 percent of the total CO in virtually all cases. [13]

The importance of the sources at various distances from the monitor supports the notion that siting criteria based largely on the distribution of sources will be adequate to define qualitatively the spatial representativeness of the station.

6.2.2 Effects of Meteorology

Wind direction establishes the general transport direction of air pollutants. The impact points are determined by the trajectory of the polluted air parcel.

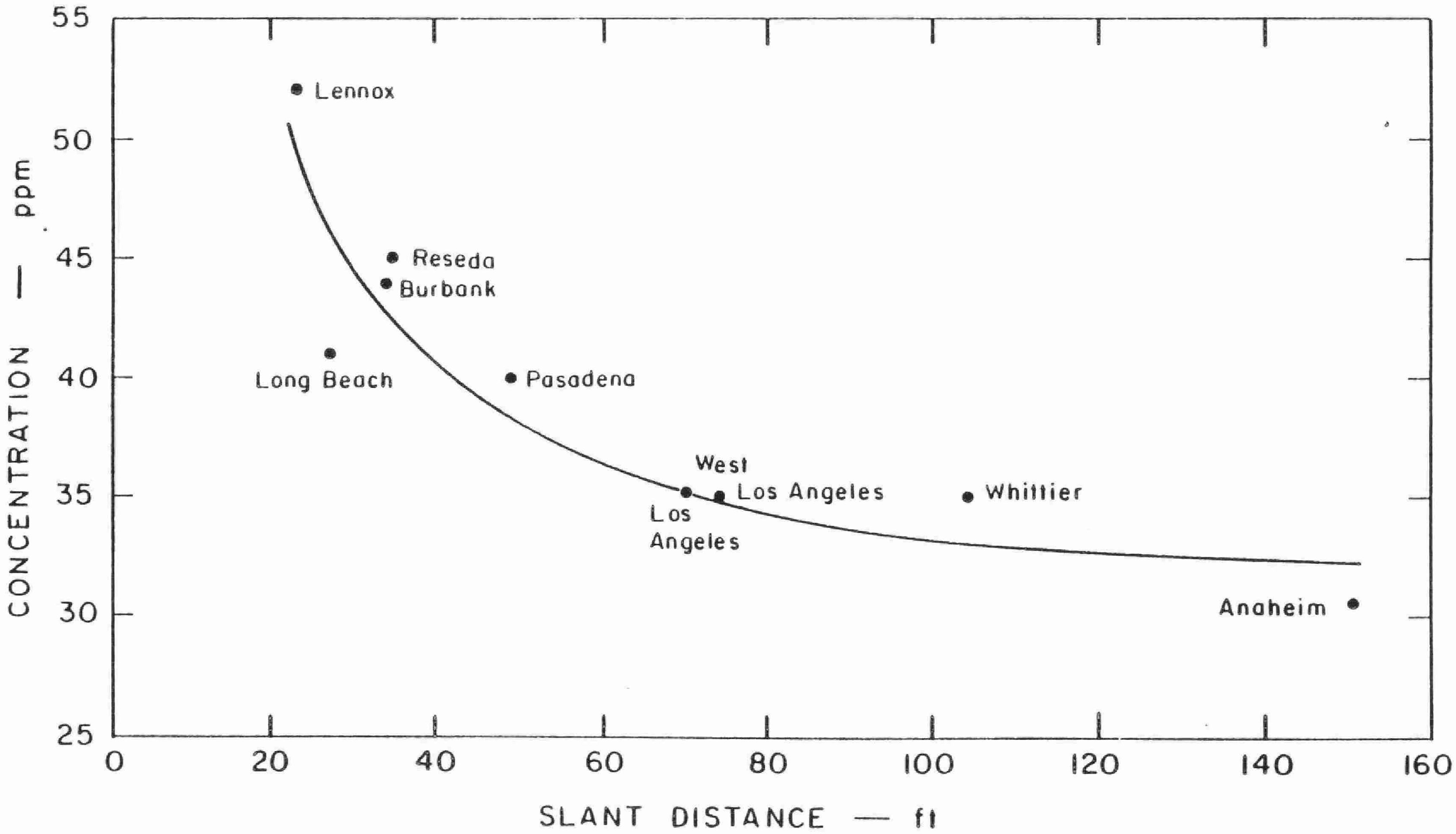


FIGURE **27** AVERAGES OF THE 1969-1970 ANNUAL MAXIMUM HOURLY CO CONCENTRATIONS VERSUS SLANT DISTANCES TO THE STREET

This trajectory is seldom a straight line due to the effects of obstructions. These obstructions include buildings, hills and valleys, and other air masses.

When the air parcel passes between two obstructions, e.g., two buildings, or over a hill, it will be squeezed horizontally and vertically, respectively. In either case, stretching of the parcel longitudinally will take place, resulting in a faster air flow. As shown in Figure 28, the reverse will occur for parcels moving across a valley: vertical stretching and longitudinal squeezing. [11]

On a longer time basis, dilution climatology has to be considered. Dilution climatology is defined as the long-term average combination of those meteorological conditions that affect the interchange and dispersion of pollutants over relatively large areas and long time intervals. [5] These factors, the frequency in height variations of wind (direction and speed), mixing heights, and stable air layers (inversion), collectively provide a measure of the dilution climatology of a relatively large area.

Dilution climatology also accounts for all the effects of large scale topographic features such as the Great Lakes and mountains. The relative frequency of recurrence of short-term phenomena such as stagnation episodes is also considered.

6.2.3 Effects of Natural Topography

The most significant topographical factors for the Toronto area are the shoreline and valley effects. Since Toronto is situated along the shore of Lake

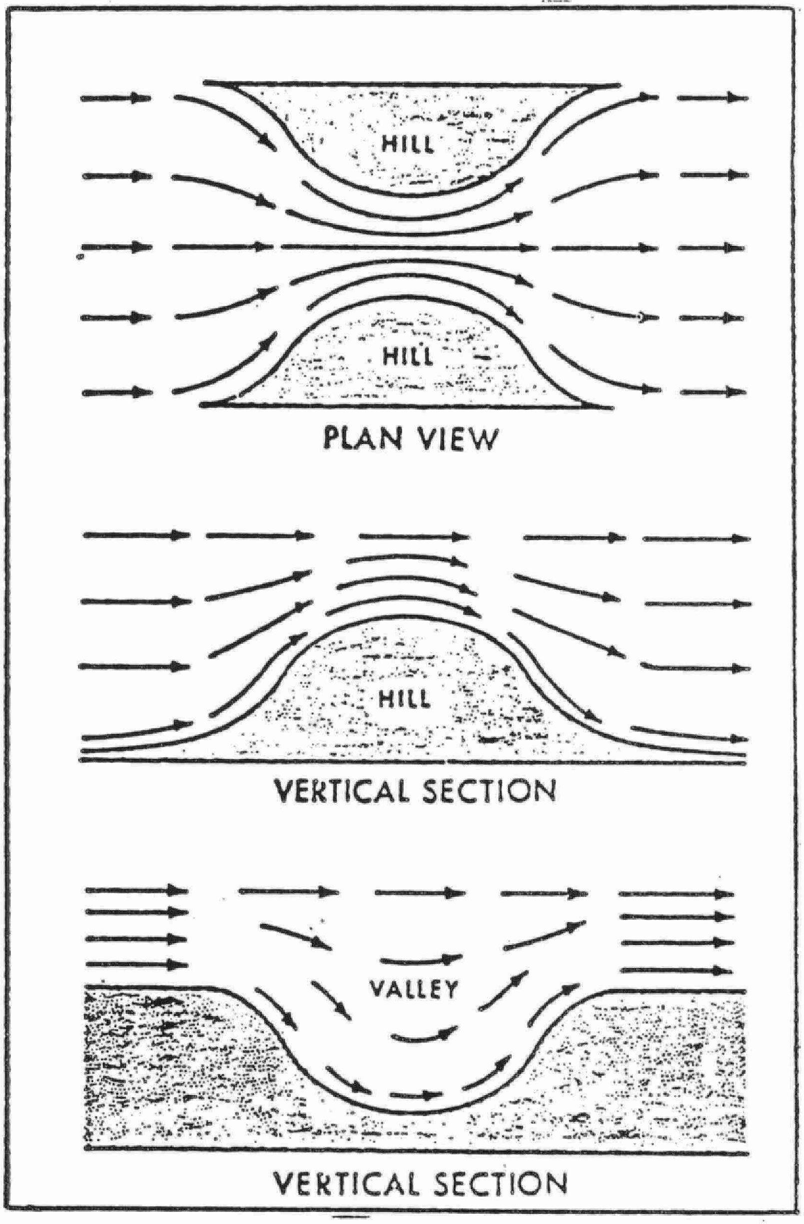


FIGURE 28 : Topography effects on wind. Length of arrow is proportional to the wind speed.

Ontario, airflow along the lakeshore undergoes frequent changes brought about by the changes in relative temperature of the air and water. This phenomenon results in the discontinuities and convergence zones in the dispersion patterns which dictate increased monitoring.

The Humber and the Don Rivers have cut deep ravines in the Metro area. Valleys tend to channel the wind flow along their axis, restrict horizontal dispersion, and increase the tendency for inversions to form. They may also cause aerodynamic downwash from stacks not extending above the valley walls. Discontinuities in the air quality patterns often result between valleys and ridges which necessitate monitoring beyond the minimum needs for level terrain.

The effects of valley-ridge topography on SO_2 levels depend on such factors as when and where the SO_2 is emitted, the height of emission, and the prevailing meteorological conditions. An SO_2 plume emitted from the top of the valley may be caught up in a cavity wake (downwash) and brought down into the valley. At night, an SO_2 plume released at a higher velocity may escape the valley and the surrounding high terrain completely.

In the case of an ozone monitor, a valley site is not recommended. In a valley, cold air drainage and stable conditions will cause air to remain relatively stagnant and without vertical mixing. This condition is prominent at night. The destructive processes at the surface will quickly deplete any ozone that is present. Hence, the measurements will not be representative of the typical values.

Trees can also obstruct an otherwise smooth wind flow and thus increase mechanical turbulance. Large trees that are closely grouped together may have the same effect on wind patterns as a small hill and produce wake cavities (Figure 29).[14] Small or scattered trees, and low vegetation can have the same effect as rough topography and increase mechanical turbulence. Due to such turbulence, moderately rough natural topography will decrease the pollutant concentration by increasing mixing.

6.2.4 Effects of Urbanization

The effects of urbanization on such meteorological elements as wind, temperature (vertical and horizontal distributions), humidity and precipitation is vital in the dispersal of pollutants. The urban "heat island" phenomenon has been well documented.

Nightime temperatures in large cities are higher than those in the surrounding rural areas. On the whole, the larger the city and more intense the nocturnal inversion, the larger the temperature differential. When a heat island circulation exists, individual pollutant plumes may tend to converge toward the center of the city where they will rise, then return aloft to the periphery of the urban area and return again, completing the circulation (convergence at low levels, divergence aloft).[11] (See Figure 30)

Heat island circulations break down under stronger wind speed conditions, particularly during the daytime. The complex building wake patterns in the urban core then become a major factor in influencing the concentrations and patterns of such pollutant as SO_2.

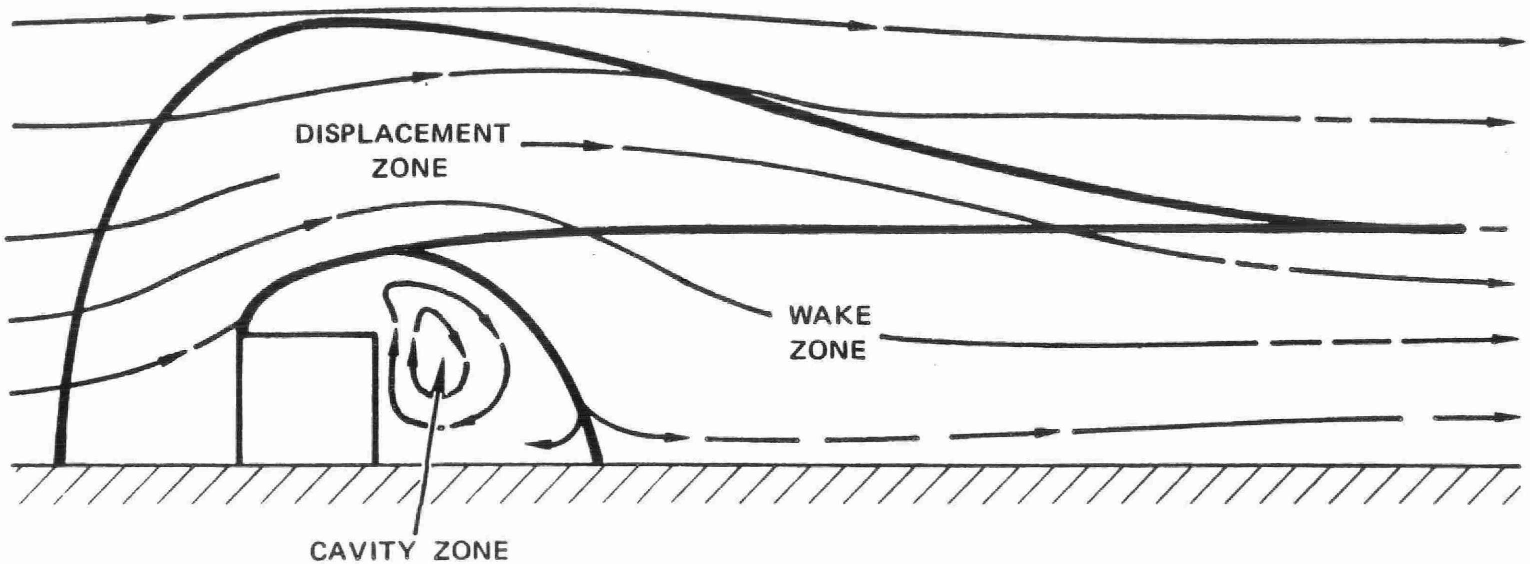


FIGURE 29 SCHEMATIC REPRESENTATION OF THE AIRFLOW AROUND AN OBSTACLE

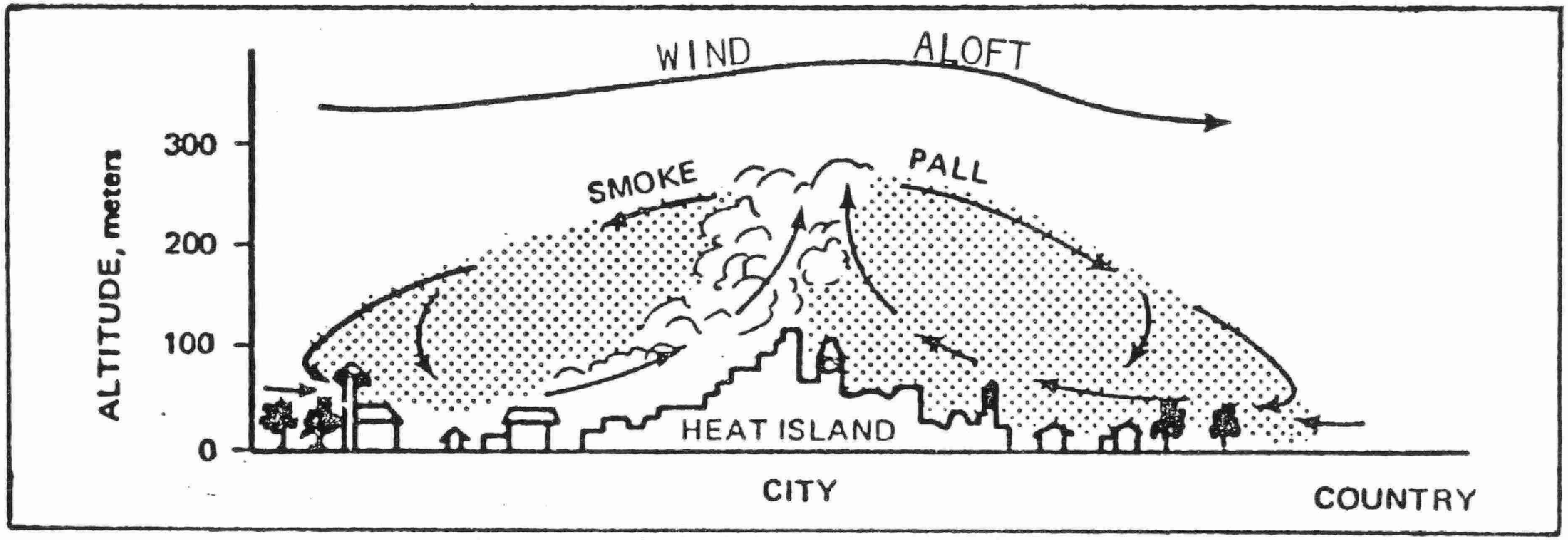


FIGURE 30 . Urban circulation and dispersion before sunrise.

In addition, higher surface temperatures in urban areas reduce atmospheric stability. This, together with increased mixing heights and mechanical turbulence, tend to enhance the vertical mixing and dispersal of pollutants.

6.3 OTHER FACTORS AFFECTING NETWORK DESIGN

Although the site selection procedures and criteria play an intricate role in network designs, there are other aspects that are equally important. Thus far, the monitoring objectives have been carefully defined and emphasized; extensive background materials have been prepared; siting criteria and procedures have been outlined; and the rationale behind some of the siting factors have been discussed. In this section, the other facets of the design process will be examined so as to make the network a complete and successful one.

The proper design of an air monitoring network involves not only air quality surveillance, but also meteorological monitoring, instrumentation and calibration, data acquisition system and data analysis (Figure 31). Failure to recognize this fact at the onset results in a design based on practical compromises that fail to meet the sampling objectives. [28]

Once the parameters to be measured are defined, sampling methods and proper instrumentation must be chosen. Factors under consideration include sampling frequency, manpower requirements, the number of monitoring sites, the distance between sites, and the duration of the survey. A cost effective system should reflect the reality of current air monitoring technology.

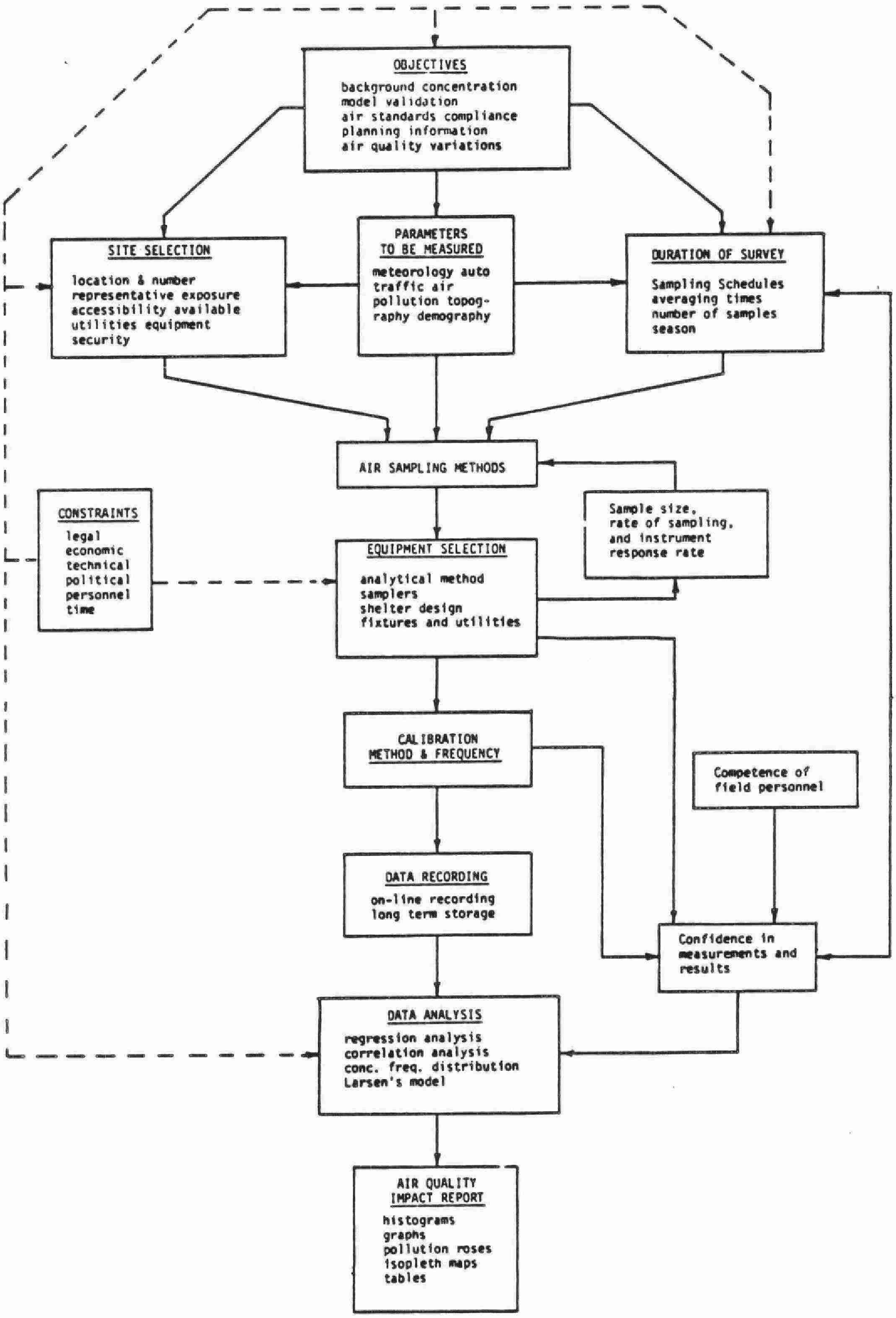


Figure 31 "Ten Step" procedure for designing an air sampling survey.

For confident measurements, accurate calibration of the equipment must be available. Ease of calibration is an asset in the operating routine.

Data recording methods are important whether they are strip chart recorders, analog or digital electronic data loggers, or on-line telemetry system. Real-time data are vital in emergency episodes and abatement actions; thus a sophisticated computerized telemetry system is highly desirable. However, strip chart recorders still serve as useful backup. Abnormality in field measurements can often be spotted easily on a strip chart but not on a computer printout.

The final step is the analysis and reporting of data. Since air quality data are highly variable, sufficient temporal and spatial resolution must be obtained. A phenomenal amount of data is also generated each year. A network of 11 stations with 12 parameters each will yield approximately 1.1 million hourly-average measurements annually. Hence various computerized statistical methods must be used to adequately analyze the massive data base.

The reporting and presentation of the results will complete the network design process. Air quality data can be presented in various forms, depending on the relationship one wishes to best illustrate. Graphs of pollution versus time may be best to demonstrate diurnal, daily, or seasonal variations. Wind and pollution roses can be prepared to illustrate the relationship between pollution concentration and different meteorological variables. The frequency of occurrence of certain pollution levels can be presented by plotting the cumulative frequency distribution on log probability graph paper. Isopleth maps showing average pollution concentrations may be the best form in displaying monitoring data of the entire network.

7.0 AIR MONITORING NETWORK FOR METROPOLITAN TORONTO

In this section, the final proposed AQI network will be presented; but first, the existing network will be reviewed below.

7.1 EXISTING AMBIENT AIR MONITORING NETWORK

Prior to the reorganization of the Ministry in 1974, an extensive network of ambient air monitoring stations was established to document the effectiveness of emission regulations. The objective of the regulations was to meet the desirable ambient air quality criteria set forth in the Air Pollution Control Act (1967). The network has since evolved to meet the changing needs of the monitoring program.

The existing ambient air monitoring network for Metropolitan Toronto is presented in Figure 32. There are three fully-equipped continuous monitoring stations in the City of Toronto, two each in North York and Etobicoke, and one in Scarborough. There is none in East York and York. Six of the eight stations are on the existing telemetering system, whereby real-time data are readily available.

The full instrumentation at these sites provides the continuous monitoring for all the standard gaseous pollutants, i.e., SO_2, CO, NO_2, NO, Hc, and O_3. Coefficient of Haze tape samplers are also operated at some of these stations.

Two- and three-level winds and temperatures are measured at the Scarborough and Etobicoke sites (Station 33003 and 35033, respectively). Single level wind is also monitored at the

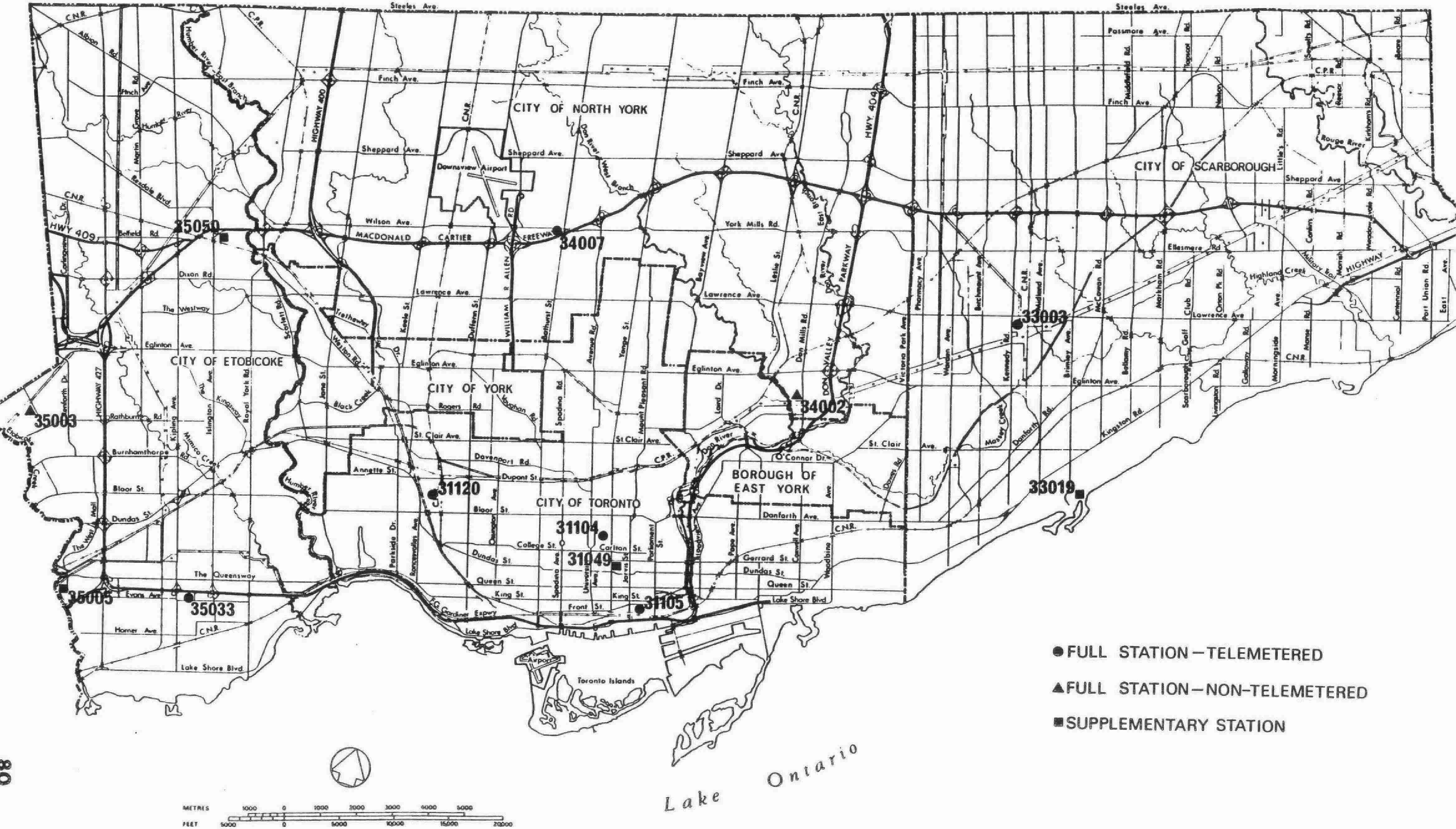


FIGURE 32: EXISTING CONTINUOUS AMBIENT AIR MONITORING NETWORK FOR METROPOLITAN TORONTO

Junction Triangle station (31120). Station 31104 in the downtown core is the API station for the Metro area.

Several sites with one or two instruments exist to supplement the network. The most significant one is the downtown street canyon station where CO and NO_x are measured continuously.

Beside the continuous monitors, an extensive particulate network was also implemented. Data from high-volume samplers, COH tape samplers, dichotomous samplers, and dustfall jars are obtained. Hi-vols and dustfall jars are installed at all continuous monitoring stations. Dichotomous sampling is regularly carried out at the API station (31104). There are routine and special sampling programs to provide data bases for numerous research projects. Through the years, there has been and continues to be, an increase in the number of stations and the number of physical parameters monitored.

7.2 PROPOSED AQI MONITORING NETWORK

As discussed in Section 3.4, an overlay technique was used to determine prospective areas within which monitoring stations might be located.

Since the AQI concerns population exposure, areas with the densest population are given first consideration. From the population density map in Figure 13, the top two fractions (i.e.> 6,000/km^2) were highlighted and transferred to a base map (Figure 33).

On a separate map, the highest fraction of the sensitive population was extracted and conveyed from Figure 14a and 14b. This included areas with 10% of the population between

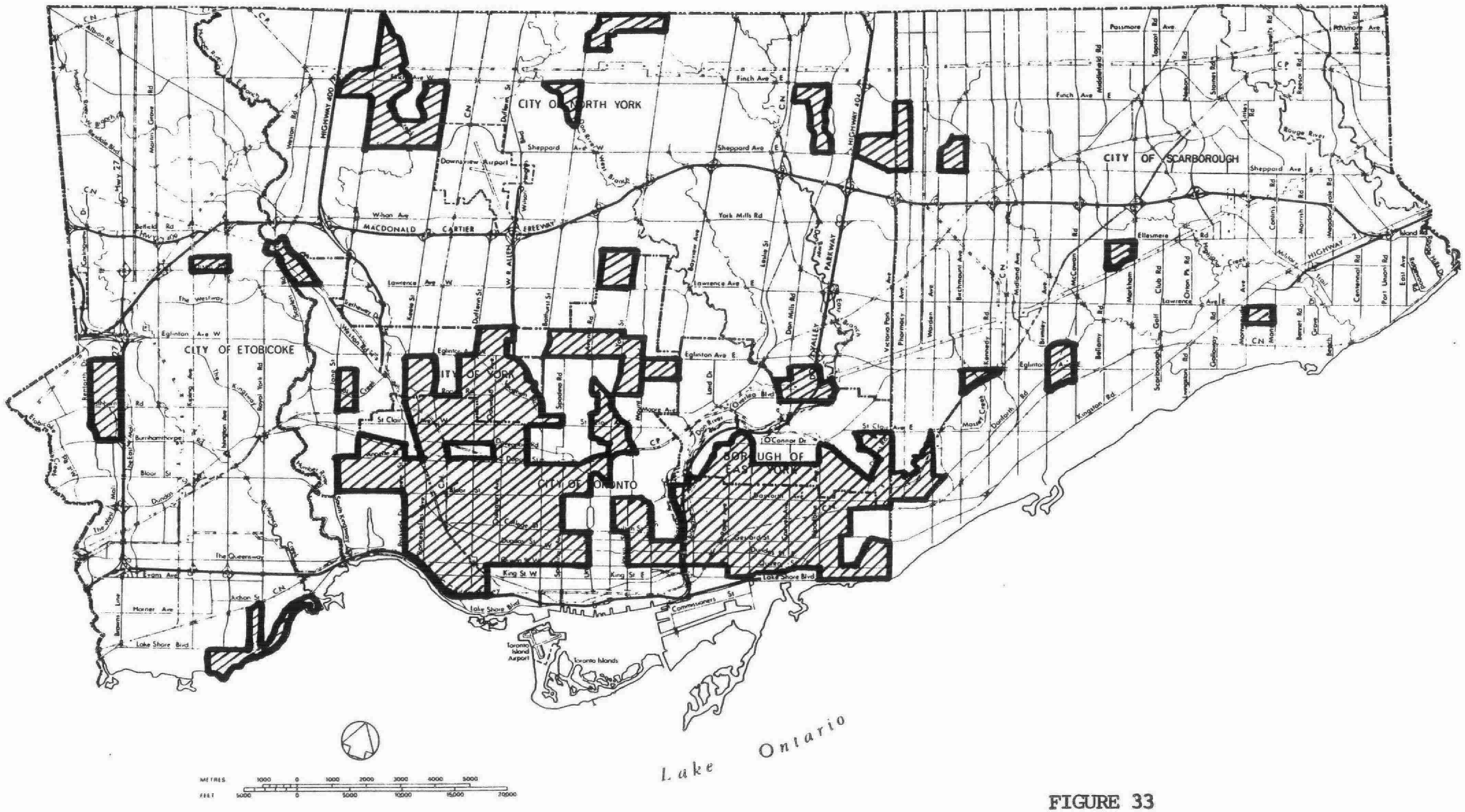


FIGURE 33

POPULATION DENSITY: 6,000 & OVER PER SQ.KM.

(BY CENSUS TRACTS)

0 and 5 years of age, and over 20% of the population over 65 (Figure 34). This map can be added to Figure 33 to give a map showing areas with the densest and the most sensitive population.

From a general land use map, less desirable areas such as industrial areas, traffic corridors, and valleys were highlighted and transferred to a third base map (Figure 35). This negative factor overlay was then combined with the others. Figure 35 represents the first group of candidate areas prior to further refinement.

Siting criteria and procedures as outlined in Section 4 were observed and followed. Numerous background information and factors were examined, including the effects of natural topography, meteorology, socio-economic impact, emission sources and distribution and complaints. Further consideration and refinements were made, ensuring the final prospective areas would meet the monitoring objectives set forth in Section 3.1. These general areas are illustrated in Figure 36.

Field trips to these candidate areas were made. Potential monitoring station sites (specific) were selected, based on the criteria outlined in Section 5. Practical aspects of station siting such as power supply and accessibility were considered. The final proposed AQI monitoring network for Metropolitan Toronto is presented in Figure 37.

Co-operation will be sought from each of the six municipalities in finalizing the exact location of the monitoring stations. With the participation of the municipalities, the implementation of the AQI and the public perception of the new concept will be greatly enhanced.

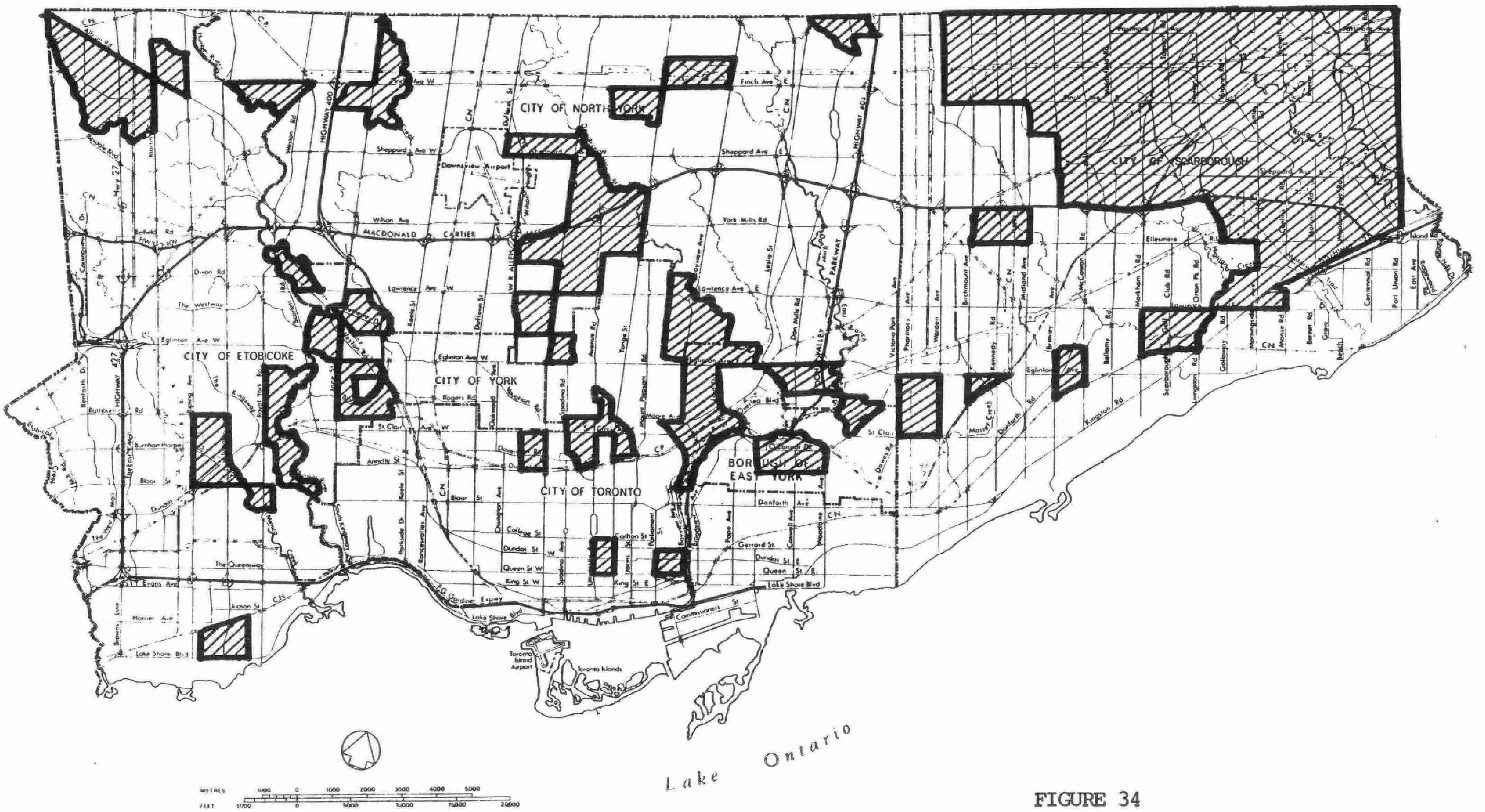


FIGURE 34

SENSITIVE POPULATION: 10% & OVER (0-5 YEARS)
AND 20% & OVER (OVER 65 YEARS)
(BY CENSUS TRACTS)

FIGURE 35

LESS DESIRABLE AREAS FOR SITING AQI MONITORING STATIONS

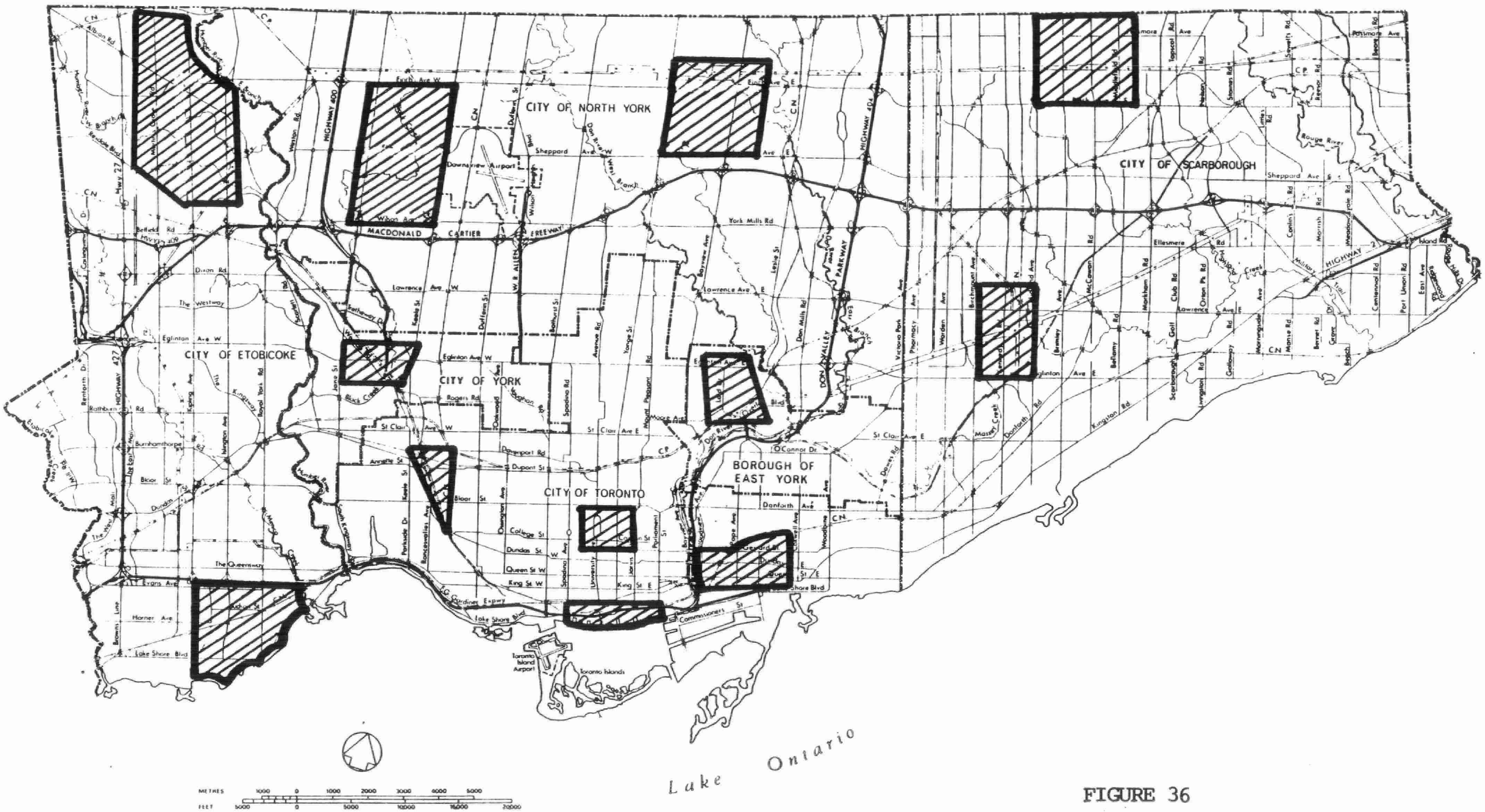


FIGURE 36

PROSPECTIVE GENERAL AREAS FOR AQI MONITORING STATIONS

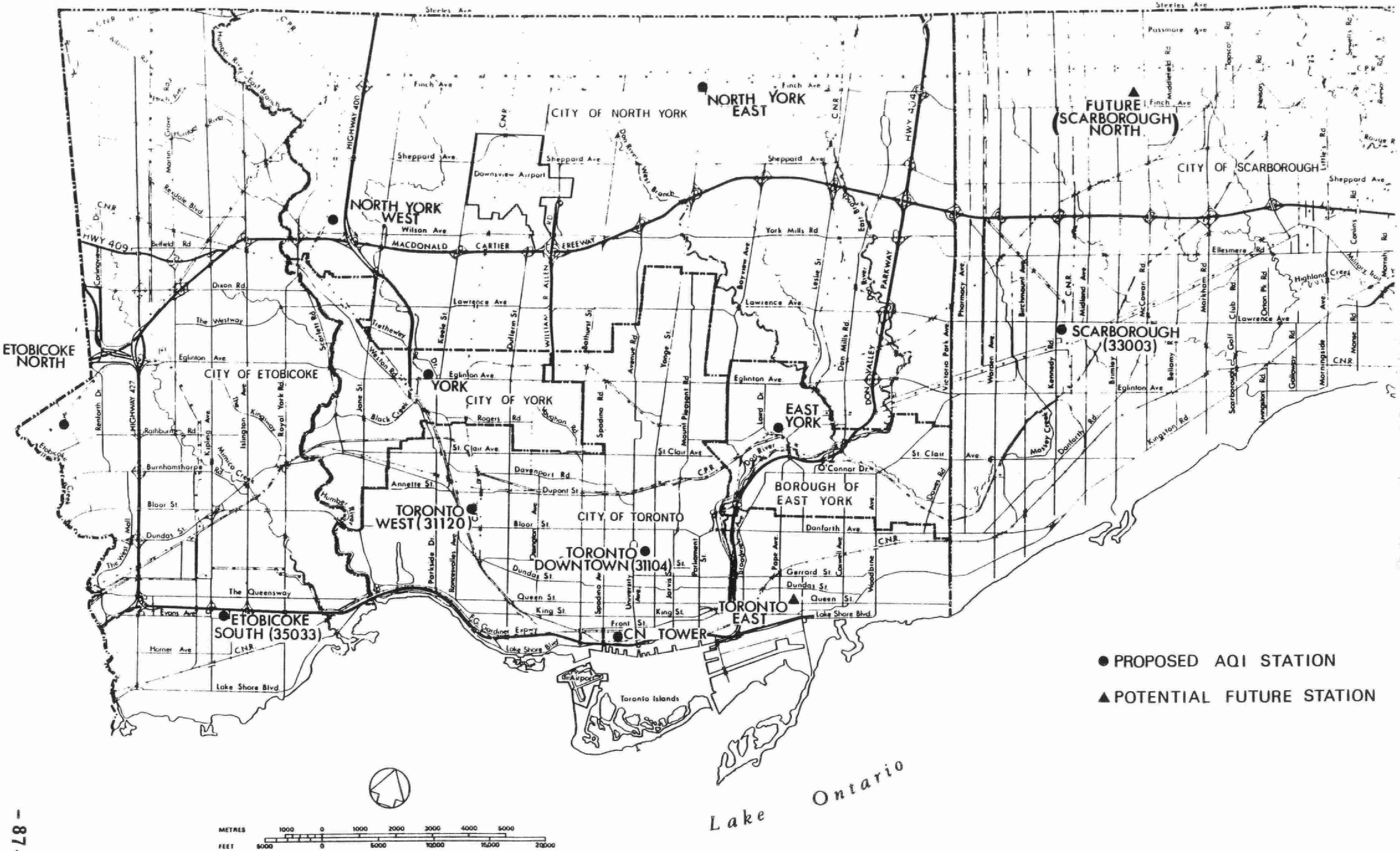


FIGURE 37: PROPOSED AQI MONITORING NETWORK FOR METROPOLITAN TORONTO

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APPENDIX A

LIST OF POINT SOURCES IN METROPOLITAN TORONTO

Toronto Point Sources Arranged By Company Name

	Easting	Northing	
00001	6230	48319	28027 Ontario Ltd
00002	6334	48356	ACME Paper Prd. Co Ltd.
00003	6382	48433	Adams Brands Limited
00004	6371	48424	Alcan Canada Foil
00005	6253	48345	Algood Div of Alcan
00006	6252	48355	American Std Products
00007	6251	48351	Anchor Cap & Closure
00008	6356	48352	Ashbridges
00009	6389	48479	Atlantic Packaging
00010	6304	48338	Bank of Nova Scotia
00011	6225	48366	Banner Packing Ltd.
00012	6268	48327	Barrymore Carpet Ltd.
00013	6478	48540	Beare Road (Landfill Site)
00014	6396	48480	Bick's Pickles
00015	6219	48308	Bishop Fibre Tek.Inc. .
00016	6479	48472	Borden Chemical
00017	6455	48500	Boro of Scarborough(Landfill Site)
00018	6409	48515	C P Rail Toronto yard
00019	6237	48357	Cadet Cleaners Ltd.
00020	6207	48288	Campbell Soup Co Ltd.
00021	6183	48402	Can Gypsum Co Ltd.
00022	6318	48406	Can Wire & Cable LTD.
00023	6292	48322	Canada Malting Co Ltd.
00024	6342	48349	Canada Metal Co Ltd.
00025	6229	48365	Canada Packers Inc.
00026	6328	48344	Canada Packers Inc.
00027	6241	48395	Canadian Industrial Ltd.
00028	6384	48428	Canadian SKF Co Ltd
00029	6323	48337	Canron Ltd
00030	6138	48366	Carling Breweries Ltd.
00031	6338	48340	Centennial College
00032	6224	48314	Christie Brown Ltd
00033	6176	48276	Chrysler Canada Ltd.
00034	6415	48507	Cinram Ltd.
00035	6341	48349	Clarke A.R.Co Ltd
00036	6334	48353	Colgate-Palmolive Ltd
00037	6337	48341	Commissioners Incin.
00038	6380	48425	Commodore Business Machines
00039	6348	48345	Compressed Metals
00040	6263	48494	Connaught Med. Reslab.
00041	6187	48316	Consumer Glass Co
00042	6209	48285	Continental Can Co
00043	6366	48530	Crushall Aggregates
00044	6208	48394	Dominion Bridge Co
00045	6207	48392	Dominion Cellulose
00046	6322	48393	Domtar Fine Paper
00047	6184	48301	Domtar Packaging ltd.
00048	6185	48446	Dow Chemical Ltd
00049	6147	48405	Dufferin Mat.& Const.
00050	6186	48431	Eatons Co Ltd.
00051	6193	48289	Emery Industries CDA
00052	6322	48409	Floorco Limited
00053	6145	48410	General Mills Ltd.
00054	6381	48427	General Motors of Canada
00055	6193	48288	Gilbey Canada Ltd.
00056	6246	48352	Glidden Company
00057	6202	48283	Goodyear Tire & Rubber
00058	6247	48348	Grinnell Co Canada

Toronto Point Sources Arranged By Company Name

	Easting	Northing	
00059	6218	48477	Gulf Oil Canada Ltd
00060	6389	48479	Halo Plastic Bag Mfg.
00061	6144	48401	Hauserman Ltd.
00062	6265	48363	Hepburn John Ltd.
00063	6126	48435	Humber College
00064	6343	48474	IBM
00065	6338	48415	IBM Canada Ltd
00066	6222	48469	Imperial Oil Limited
00067	6182	48433	Indalloy Division of Indal Ltd
00068	6249	48359	Inmont Canada Ltd.
00069	6388	48492	International Waxes
00070	6142	48409	Jacuzzi Canada Ltd.
00071	6177	48305	Jao. F. Gillanders Ltd.
00072	6278	48327	John Inglis Co ltd.
00073	6311	48339	King Edward Sheraton
00074	6221	48383	Kodak Canadian Inc.
00075	6172	48404	Labatts Ont. Brewery
00076	6254	48353	Lansdowne Garage
00077	6110	48451	Lawrason's Chemicals
00078	6329	48345	Lever Brothers Ltd.
00079	6289	48325	Loblaws Groc. Co. Ltd.
00080	6282	48458	Maclean Hunter Ltd
00081	6302	48364	Manufactures Life
00082	6498	48488	Manville Canada Ltd.
00083	6279	48329	Massey Ferguson Ltd.
00084	6208	48308	Mcguinness Distillry
00085	6326	48409	Metal & Alloys Co Ltd
00086	6456	48517	Miller Paving Ltd
00087	6481	48472	Mobil Paint Co.
00088	6286	48324	Molson
00089	6145	48393	Monarch fine Food
00090	6235	48363	National Oil
00091	6193	48293	National Silicates Ltd.
00092	6307	48338	National Trust Bldg.
00093	6265	48342	Neilson WM Limited
00094	6253	48478	North York Branson
00095	6315	48474	North York Gen.Hosp
00096	6192	48288	Northern Pigment Co.
00097	6478	48472	Organon Canada Ltd.
00098	6177	48275	PPG Industries Canada
00099	6285	48339	Parisian LDY TO Ltd.
00100	6255	48335	Parkdale Garage
00101	6252	48396	Patons and Baldwins
00102	6225	48466	Petro Canada
00103	6323	48412	Philps electronics
00104	6165	48411	Photo Engravers
00105	6392	48402	Pilkington Glass
00106	6263	48324	Queen Elizabeth Hospital
00107	6164	48298	Queensway Gen. Hospital
00108	6417	48459	ROHM & HAAS Co.
00109	6312	48332	Redpath Sugar
00110	6318	48353	Regent Pk Nth Cnthtg
00111	6185	48414	Reichold Chemicals
00112	6173	48457	Reynolds Aluminum
00113	6258	48360	Ridgeline Products
00114	6324	48358	Riverdale Hospital
00115	6319	48401	Robinson E.S.& A.
00116	6241	48415	Rothmans of P.M.Can.
00117	6330	48343	Rothsay Division of Maple Leaf

Toronto Point Sources Arranged By Company Name

	Easting	Northing	
00118	6305	48338	Royal Bank of Canada
00119	6305	48349	Ryerson Polytec. Inst.
00120	6293	48508	SIS/St JOS Convent.
00121	6185	48402	Satin Fin Floor Ltd.
00122	6413	48458	Scarborough Gen.Hosp
00123	6341	48344	Shell (Toronto)
00124	6255	48336	Sherwin Williams Co
00125	6164	48412	Simpson-Sears W/H
00126	6185	48427	Southam Murray Ltd.
00127	6306	48344	St.Michaels Hospital
00128	6196	48288	Stauffer Chemicals
00129	6232	48325	Steel Company Canada
00130	6335	48340	Sun Oil Co ltd
00131	6308	48419	Sunnybrook Hospital
00132	6478	48469	Surpass Chemicals
00133	6331	48332	Texaco
00134	6217	48478	Texaco Canada (Toronto)
00135	6304	48331	Tor Term Ctr Htg Plt.
00136	6347	48384	Tor.East General
00137	6300	48348	Tor.Hosp.Corp.Steam Plt.
00138	6301	48338	Tor.Hyd Ctrl Ht Plt.
00139	6206	48299	Toronto Area Transit
00140	6275	48354	Toronto Broad of Education
00141	6286	48329	Toronto Ref.& Smelters
00142	6284	48344	Toronto Western Hosp.
00143	6331	48411	Tremco Mfg. Co Ltd
00144	6227	48367	Universal Drum
00145	6291	48351	University Toronto
00146	6322	48336	Victory Soya Mills
00147	6145	48400	Vulcan Industrial Packaging Ltd.
00148	6256	48337	Wabash Auto Service
00149	6221	48461	Warren Bit Paving Co
00150	6306	48359	Wellesley Hospital
00151	6202	48383	West Toronto Hospital
00152	6140	48406	York Litho
00153	6211	48485	York University
00154	6246	48426	Yorkdale Plaza

Toronto Point Sources Arranged by UTM Coordinates

	Easting	Northing	
00001	6110	48451	Lawrason's Chemicals
00002	6126	48435	Humber College
00003	6138	48366	Carling Breweries Ltd.
00004	6140	48406	York Litho
00005	6142	48409	Jacuzzi Canada Ltd.
00006	6144	48401	Hauserman Ltd.
00007	6145	48393	Monarch fine Food
00008	6145	48400	Vulcan Industrial Packaging Ltd.
00009	6145	48410	General Mills Ltd.
00010	6147	48405	Dufferin Mat.& Const.
00011	6164	48298	Queensway Gen. Hospital
00012	6164	48412	Simpson-Sears W/H
00013	6165	48411	Photo Engravers
00014	6172	48407	Labatts Ont. Brewery
00015	6173	48457	Reynolds Aluminum
00016	6176	48276	Chrysler Canada Ltd.
00017	6177	48275	PPG Industries Canada
00018	6177	48305	Jao. F. Gillanders Ltd.
00019	6182	48433	Indalloy Division of Indal Ltd
00020	6183	48402	Can Gypsum Co Ltd.
00021	6184	48301	Domtar Packaging ltd.
00022	6185	48402	Satin Fin Floor Ltd.
00023	6185	48414	Reichold Chemicals
00024	6185	48427	Southam Murray Ltd.
00025	6185	48446	Dow Chemical Ltd
00026	6186	48431	Eatons Co Ltd.
00027	6187	48316	Consumer Glass Co
00028	6192	48288	Northern Pigment Co.
00029	6193	48288	Gilbey Canada Ltd.
00030	6193	48289	Emery Industries CDA
00031	6193	48293	National Silicates Ltd.
00032	6196	48288	Stauffer Chemicals
00033	6202	48283	Goodyear Tire & Rubber
00034	6202	48383	West Toronto Hospital
00035	6206	48299	Toronto Area Transit
00036	6207	48288	Campbell Soup Co Ltd.
00037	6207	48392	Dominion Cellulose
00038	6208	48308	Mcguinness Distillry
00039	6208	48394	Dominion Bridge Co
00040	6209	48285	Continental Can Co
00041	6211	48485	York University
00042	6217	48478	Texaco Canada (Toronto)
00043	6218	48477	Gulf Oil Canada Ltd
00044	6219	48308	Bishop Fibre Tek.Inc.
00045	6221	48383	Kodak Canadian Inc.
00046	6221	48461	Warren Bit Paving Co
00047	6222	48469	Imperial Oil Limited
00048	6224	48314	Christie Brown Ltd
00049	6225	48366	Banner Packing Ltd.
00050	6225	48466	Petro Canada
00051	6227	48367	Universal Drum
00052	6229	48365	Canada Packers Inc.
00053	6230	48319	28027 Ontario Ltd
00054	6232	48325	Steel Company Canada
00055	6235	48363	National Oil
00056	6237	48357	Cadet Cleaners Ltd.
00057	6241	48395	Canadian Industrial Ltd.
00058	6241	48415	Rothmans of P.M.Can.

Toronto Point Sources Arranged by UTM Coordinates

	Easting	Northing	
00059	6246	48352	Glidden Company
00060	6246	48426	Yorkdale Plaza
00061	6247	48348	Grinnell Co Canada
00062	6249	48359	Inmont Canada Ltd.
00063	6251	48351	Anchor Cap & Closure
00064	6252	48355	American Std Products
00065	6252	48396	Patons and Baldwins
00066	6253	48345	Algood Div of Alcan
00067	6253	48478	North York Branson
00068	6254	48353	Lansdowne Garage
00069	6255	48335	Parkdale Garage
00070	6255	48336	Sherwin Williams Co
00071	6256	48337	Wabash Auto Service
00072	6258	48360	Ridgeline Products
00073	6263	48324	Queen Elizabeth Hospital
00074	6263	48494	Connaught Med. Reslab.
00075	6265	48342	Neilson WM Limited
00076	6265	48363	Hepburn John Ltd.
00077	6268	48327	Barrymore Carpet Ltd.
00078	6275	48354	Toronto Broad of Education
00079	6278	48327	John Inglis Co ltd.
00080	6279	48329	Massey Ferguson Ltd.
00081	6282	48458	Maclean Hunter Ltd
00082	6284	48344	Toronto Western Hosp.
00083	6285	48339	Parisian LDY TO Ltd.
00084	6286	48324	Molson
00085	6286	48329	Toronto Ref.& Smelters
00086	6289	48325	Loblaws Groc. Co. Ltd.
00087	6291	48351	University Toronto
00088	6292	48322	Canada Malting Co Ltd.
00089	6293	48508	SIS/St JOS Convent.
00090	6300	48348	Tor.Hosp.Corp.Steam Plt.
00091	6301	48338	Tor.Hyd Ctrl Ht Plt.
00092	6302	48364	Manufactures Life
00093	6304	48331	Tor Term Ctr Htg Plt.
00094	6304	48338	Bank of Nova Scotia
00095	6305	48338	Royal Bank of Canada
00096	6305	48349	Ryerson Polytec. Inst.
00097	6306	48344	St.Michaels Hospital
00098	6306	48359	Wellesley Hospital
00099	6307	48338	National Trust Bldg.
00100	6308	48419	Sunnybrook Hospital
00101	6311	48339	King Edward Sheraton
00102	6312	48332	Redpath Sugar
00103	6315	48475	North York Gen.Hosp
00104	6318	48353	Regent Pk Nth Cnthtg
00105	6318	48406	Can Wire & Cable LTD.
00106	6319	48401	Robinson E.S.& A.
00107	6322	48336	Victory Soya Mills
00108	6322	48393	Domtar Fine Paper
00109	6322	48409	Floorco Limited
00110	6323	48337	Canron Ltd
00111	6323	48412	Philps electronics
00112	6324	48358	Riverdale Hospital
00113	6326	48409	Metal & Alloys Co Ltd
00114	6328	48344	Canada Packers Inc.
00115	6329	48345	Lever Brothers Ltd.
00116	6330	48343	Rothsay Division of Maple Leaf
00117	6331	48332	Texaco
00118	6331	48411	Tremco Mfg. Co Ltd

Toronto Point Sources Arranged by UTM Coordinates

	Easting	Northing	
00119	6334	48353	Colgate-Palmolive Ltd
00120	6334	48356	ACME Paper Prd. Co Ltd.
00121	6335	48340	Sun Oil Co ltd
00122	6337	48341	Commissioners Incin.
00123	6338	48340	Centennial College
00124	6338	48415	IBM Canada Ltd
00125	6341	48344	Shell (Toronto)
00126	6341	48349	Clarke A.R.Co Ltd
00127	6342	48349	Canada Metal Co Ltd.
00128	6343	48480	IBM
00129	6347	48384	Tor.East General
00130	6348	48345	Compressed Metals
00131	6356	48352	Ashbridges
00132	6366	48530	Crushall Aggregates
00133	6371	48424	Alcan Canada Foil
00134	6380	48425	Commodore Business Machines
00135	6381	48427	General Motors of Canada
00136	6382	48433	Adams Brands Limited
00137	6384	48428	Canadian SKF Co Ltd
00138	6389	48479	Halo Plastic Bag Mfg.
00139	6389	48479	Atlantic Packaging
00140	6391	48493	International Waxes
00141	6392	48402	Pilkington Glass
00142	6396	48480	Bick's Pickles
00143	6409	48515	C P Rail Toronto yard
00144	6413	48458	Scarborough Gen.Hosp
00145	6415	48507	Cinram Ltd.
00146	6417	48459	ROHM & HAAS Co.
00147	6455	48500	Boro of Scarborough(Landfill Site)
00148	6456	48517	Miller Paving Ltd
00149	6478	48469	Surpass Chemicals
00150	6478	48472	Organon Canada Ltd.
00151	6478	48540	Beare Road (Landfill Site)
00152	6479	48472	Borden Chemical
00153	6481	48472	Mobil Paint Co
00154	6498	48488	Manville Canada Ltd.

APPENDIX B

SITE DOCUMENTATION FOR A "NAPS" STATION

(NAPS = NATIONAL AIR POLLUTION SURVEILLANCE)

DOCUMENTATION ON NAPS NETWORK MONITORING STATIONS

DOCUMENTATION SUR LES STATIONS DU RÉSEAU SNPA

A. GENERAL INFORMATION/INFORMATIONS GÉNÉRALES

1. Station Identification/ Identification de la station:
   60417 — NAPS Station No./ N°. SNPA
   31104 — Agency Station No./ N°. de station de l'organisme exploitant

2. Station Name/ Nom de la station:
   ______ — Building Name, Park Name, etc./ Nom de l'immeuble, du parc, etc.

3. City/Ville:
   ______ — Borough or Municipality Name/ Nom du quartier ou de la municipalité
   TORONTO, ONTARIO — City or Metropolitan Area Name/ Nom de la ville ou de la région métropolitaine

4. Station Address/ Adresse de la station:
   26 BREADALBANE STREET — Street Number and Street Name/ N°. et nom de la rue
   BAY OR YONGE — Nearest Cross-Street/ Intersection la plus proche

5. Latitude and Longitude/ Latitude et Longitude:
   43 39 49 — Latitude
   079 23 09 — Longitude

6. UTM Co-ordinates/ Coordonnées UTM:
   0630.2 — East/Est
   4835.6 — North/Nord

7. Population:
   ______ — Pop. of Borough or Municipality/ Pop. du quartier ou de la municipalité
   ______ — Census Year/ Année de recensement
   2,803,101 — Pop. of City or Metropolitan Area/ Pop. de la ville ou de la région métropolitaine
   1976 — Census Year/ Année de recensement

8. Operating Agency/ Organisme chargé de l'exploitation:
   MINISTRY OF THE ENVIRONMENT — Agency Name/Nom
   F. AUSTIN — Operator's Name/ Nom de l'exploitant
   965-2120 — Telephone/ Téléphone

9. Time Zone/ Fuseau horaire:
   EASTERN HEURE DE L'EST — Time Zone/Fuseau horaire

10. Date:
   8106 — Date Station Established/ Date de la mise sur pied de la station
   8108 — Date Information Last Updated/ Date de la dernière remise à jour des renseignements

DOCUMENTATION ON NAPS NETWORK MONITORING STATIONS
DOCUMENTATION SUR LES STATIONS DU RÉSEAU SNPA

B. INSTRUMENT DETAILS/DÉTAILS SUR LES INSTRUMENTS

Instrument Type/ Type d'instrument	Owner/ Propriétaire	Make/ Marque	Model/ Modèle	Serial No./ N°. de série	Date Installed/ Date d'installation	Detection Principle/ Principe de détection	Range Used (ppm)/ Amplitude Utilisée (ppm)	Sampling Height Above Ground (metres)/ Hauteur de l'échantillonnage (mètres)	Sampling Line Length (metres)/ Longueur du conduit d'échantillonnage (mètres)
Suspended Particulates/ Particules en suspension	P	GMW	2000H		7012			16	
Soiling Index/ Indice de souillure	P	RAC	FI		7012	LIGHT		16	2.5
Sulphur Dioxide/ Dioxyde de soufre	P	TECO	43		7012	PF	0-0.5	16	1.5
Carbon Monoxide/ Monoxyde de carbone	F	BENDIX	8501	31646 -3	7507	IR	0-50	16	1.5
Nitrogen Dioxide/ Dioxyde d'azote	P	TECO	14D		7302	CHEMI	0-1	16	1.5
Ozone	F	BENDIX	8002	33112 -3	7502	CHEMI	0-0.5	16	1.5
Dustfall/ Retombées de poussière	P								
Sulphation/ Formation de sulfates									
Telemetry/ Contrôle à distance	X								
HC	F	BENDIX	8201	301148 -2	7512	FID	0-20	16	1.5
HC	P	BECKMAN	400		8106	FID	0-20	16	1.5

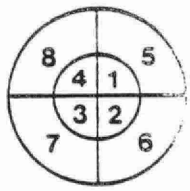
DOCUMENTATION ON NAPS NETWORK MONITORING STATIONS
DOCUMENTATION SUR LES STATIONS DU RÉSEAU SNPA

C. SITE DESCRIPTION/DESCRIPTION DE L'EMPLACEMENT

1. Scale of Representativeness/ Échelle de représentativité: NEIGHBOURHOOD/VOISINAGE

2. Land Use by Sector (see map)/ Utilisation des terres par secteur: (voir la carte)

1C2	5 C2
2C2	6 C2
3C2	7 C2
4C2	8 C2



3. Site Elevation (above sea level)/ Altitude: 104 m

4. Angle of Elevation to Nearby Buildings/ Angle d'élévation des immeubles les plus proches:
   1. Greatest Angle/ Angle le plus grand 55 °
   2. Building Direction/ Direction de l'immeuble 175 °

5. Average Building Height in Area/ Hauteur moyenne des immeubles du voisinage: 15 m

6. Airflow Restrictions (Yes/No)/ Obstacles à la circulation de l'air: (oui/non)
   North/ Nord: NO/NON
   East/ Est: NO/NON
   South/ Sud: NO/NO
   West/ Ouest: NO/NON

7. Distance to Nearest Trees/ Distance jusqu'aux arbres les plus proches: 20 m

8. Manifold/ Tuyauterie d'admission:
   1. Type: 4" GLASS
   2. Distance from Supporting Structure/ Distance de la structure portante: 1.5 M ABOVE ROOF

9. Meteorological Information/ Renseignements Météorologiques:
   1. Type: COMPLETE
   2. Address/Adresse: TORONTO ISLAND AIRPORT
   3. Distance from station/ Distance de la station: 4 km
   4. Contact/ Personne à contacter: W.F. TSE M.O.E. (416) 424-3000

DOCUMENTATION ON NAPS NETWORK MONITORING STATIONS
DOCUMENTATION SUR LES STATIONS DU RÉSEAU SNPA

D. SITE INFLUENCES/EFFETS DE L'EMPLACEMENT

1. Localized Sources/Source Locales:
(within 200 m of monitor)/(à moins de 200 m du détecteur)

Type	Distance (m)	Description
	NONE/NULLE	

2. Roadway Influences/Effets des routes:

Name/Nom	Type	Traffic Volume/ Intensité de la circulation	Distance (m)	Direction (degrees/degrés)
BAY ST.	MAJOR CITY STREET	26,200	100	270
YONGE ST.	MAJOR CITY STREET	28,000	100	90

3. Major Point Sources/Principales sources ponctuelles:

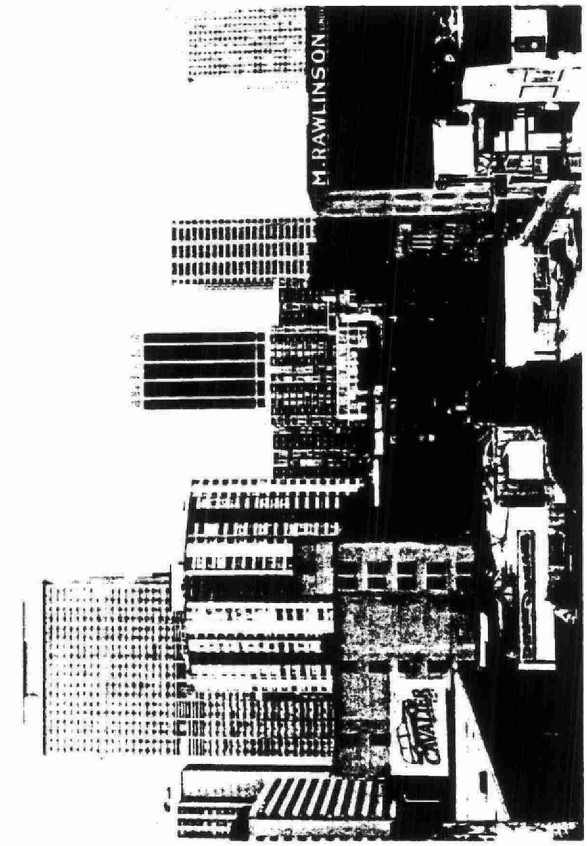
Map No./ N°. de la carte	Source Name/ Nom de la source	Source Type/ Type de source	Production Capacity/ Capacité de production	Distance from Site (km)/ Distance de l'emplacement (km)	Compass Direction (degrees)/ Direction (degrés)
1	TORONTO REFINERIES & SMELTERS	LEAD		2.9	210
2	TORONTO BRICKWORKS	FLUORIDE		2.7	35

DOCUMENTATION ON NAPS NETWORK MONITORING STATIONS
DOCUMENTATION SUR LES STATIONS RÉSEAU SNPA

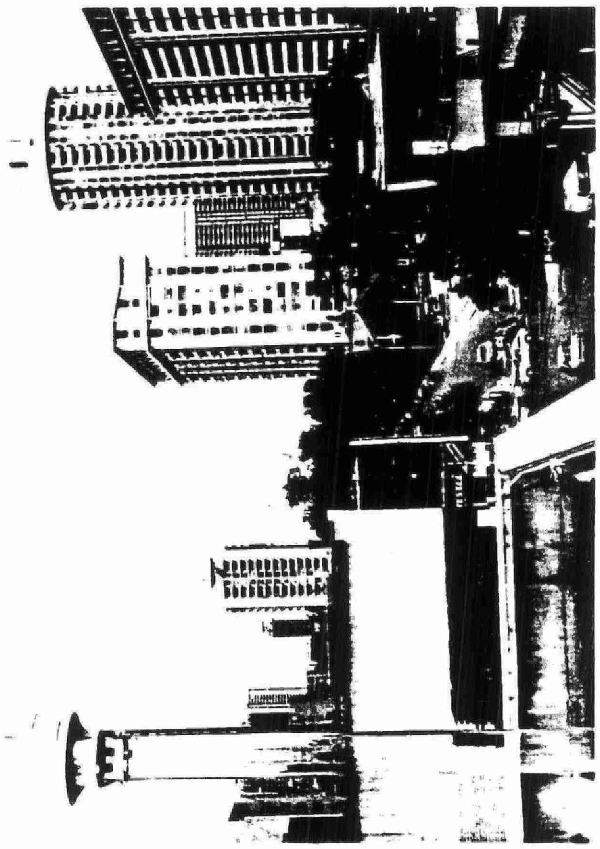
E. TOPOGRAPHIC MAP
E. CARTE TOPOGRAPHIQUE

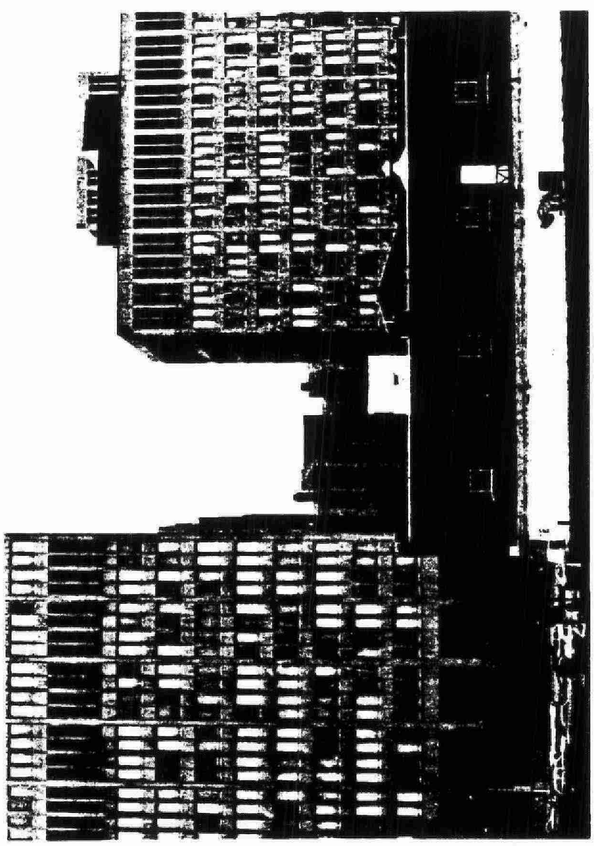
DOCUMENTATION ON NAPS NETWORK MONITORING STATIONS
DOCUMENTATION SUR LES STATIONS DU RÉSEAU SNPA

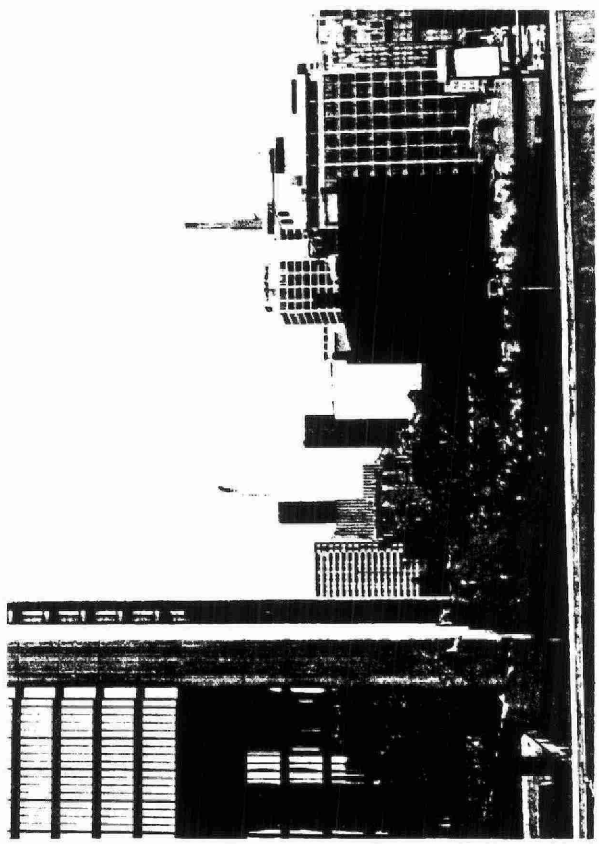
F. PHOTOGRAPHS (FROM INLET)
F. PHOTOGRAPHIES (PRISES DE L'ORIFICE D'ADMISSION)



NORTH - NORD


EAST - EST

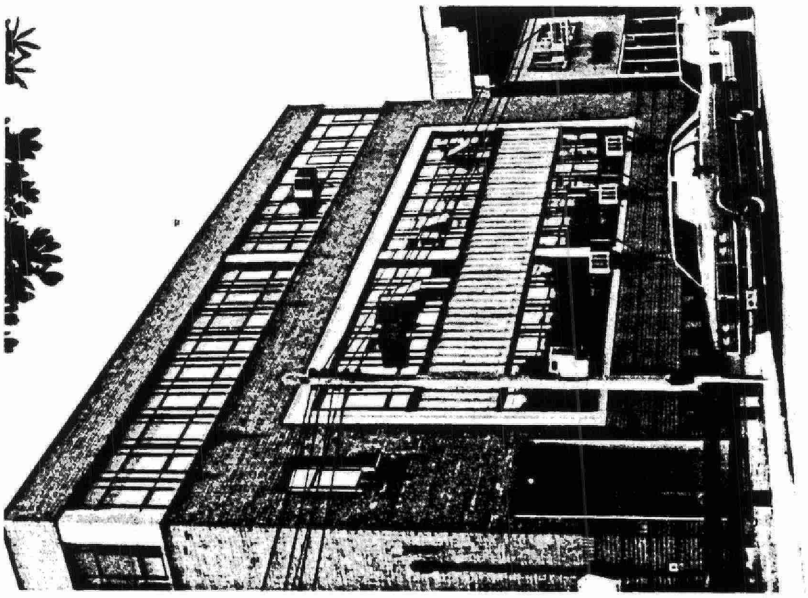

WEST - OUEST


SOUTH - SUD

NAPS NO. SNPA 60417

DOCUMENTATION ON NAPS NETWORK MONITORING STATIONS
DOCUMENTATION SUR LES STATIONS DU RÉSEAU SNPA

G. PHOTOGRAPHS (STATION)
G. PHOTOGRAPHIES (DE LA STATION)



DATE DUE / DATE DE RETOUR

ONT/MOE/1064
Tse Wing F
Air quality index (AQI)
network design for
AWJG c. 1 aa IRC